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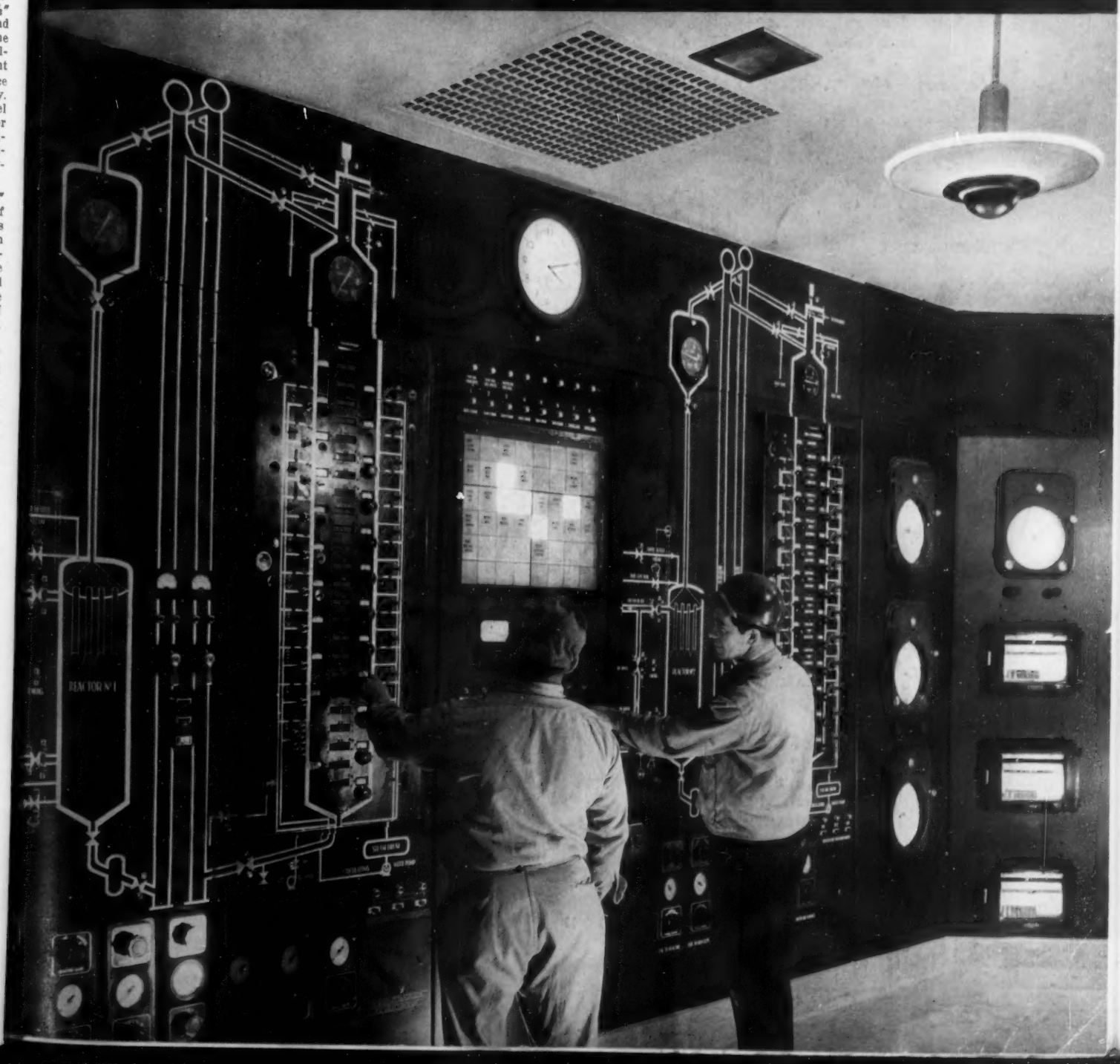
Instruments

THE MAGAZINE OF Measurement and Control



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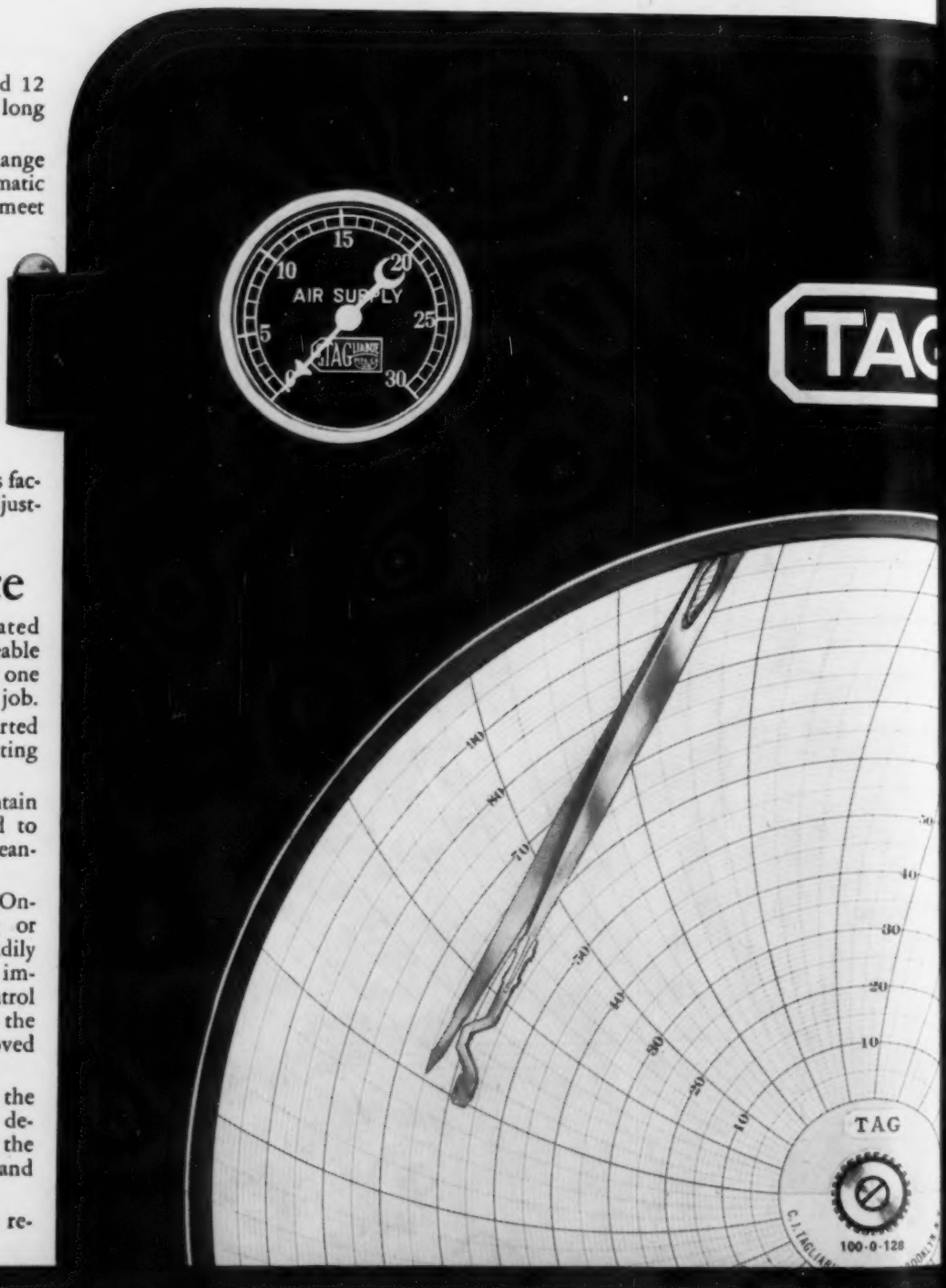

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THE MAGAZINE OF
Measurement and Control

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COVER: Control panel, twin reactor Thermofor catalytic cracking unit, Marcus Hook (Pa.) refinery of Sun Oil Co. *(See story on page 342)*

(Courtesy N. W. Ayer & Sons, for E. B. Badger & Co. and Sun Oil Co.)

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

All New Problems Are Unusual

IN his Detroit ISA Conference lecture, Dr. Grebe began by stating that he would "emphasize the wide variety of control problems." This talk was very much like the lecturer himself: John Grebe's contributions include chemical extraction of magnesium from sea-water, mechanical inventions, electromechanical devices, electrical gadgets—and, of course, his novel automatic-control systems. His Detroit talk covered the widest range of control topics ever touched upon in a single ISA meeting. But before he had been speaking for more than a quarter-hour, many persons in the audience must have begun to sense that as his *topics* became more and diversified, they actually became more and more fused together into one dominant *theme*—which we might formulate as follows:

Every problem of measurement or of automatic control differs from every other one; and BECAUSE this is so, because no two problems are alike, the best solution of each problem is the solution most firmly grounded on the simplest fundamentals most applicable to the widest variety of problems.

This particular formulation sounds paradoxical but it is the optimal approach to instrumentation problems. It really is practical because it warns practical instrument men against specializing so narrowly that they can't see the woods on account of the trees. Unlike machinists, or glass-blowers, or welders, who should not become jacks-of-all-trades, an oil-industry process-control man masters his own trade by studying gunfire control; an aircraft control man benefits by studying furnace control; and so on.

Long before Dr. Grebe finished his talk, other persons in the audience must have begun to realize that the richest portion of his lecture was a discourse within a discourse, which could have been announced as "My Philosophy of Control"—although such an announcement would be improbable because no technical-society program committee would schedule a lecture on philosophy: the strongest objectors might be those committeemen who "took philosophy" in college!

Perhaps a few persons in the audience were bored by the philosophical portions of Dr. Grebe's lecture (the very portions we print). Most of these probably were among those who "took philosophy" in college. They should not be criticized: the root fault is that the teaching of Philosophy in most of our colleges tends to make normal, healthy, intelligent students allergic for the rest of their lives to the only truly *educative* subject in the crowded curricula.

We trust, however, that those few who were skeptical or scornful of analogies between human affairs and process variables were outnumbered by our old readers whose first scorn for these analogies in our writings had vanished many years ago and had turned to acceptance. To them, Dr. Grebe's lecture must have been the high-light of the ISA's Detroit Conference. They must have enjoyed it *keenly*: not like children at a fireworks display, but like music lovers at a performance of Beethoven's Ninth.

For more than a century numerous authors in various walks of life—clergymen and generals as well as engineers and sociologists—have pointed out analogies between material and human forces, cycles, growth-and-decay phenomena, etc. Many of these writings are fascinating; some are informative, but most are sterile and inapplicable. This is not the occasion for proving their sterility and inapplicability. Suffice it to assert that the workable Philosophy of Control is thoroughly modern, that it is free from the old superficialities, that it is largely an off-shoot of the science of Instrumentation, and indeed that the name once proposed for the application of control principles to human affairs is The Greater Instrumentation. —MFB

Unusual Control Problems*

By JOHN J. GREBE, Director of Physical Research Laboratory, The Dow Chemical Co., Midland, Mich.

OUR object today is to outline the science of automatic control by emphasizing the wide variety of control problems; and try to leave you with a broader conception of your profession in its relation to human efforts at control and regulation.

Actually this science is very straightforward — so simple that you unconsciously practice its principles continually. Driving your car, or giving the baby a ride in a swing, are good illustrations that apply all through Nature. So—let's start by listing the various natural cyclic factors entering into control action.

The least-known and the highest-frequency cyclic phenomena in Mother Nature are the deBroglie matter waves.

A Guest Editorial

They are the internal vibrations or the "shimmy" inside of electrons, protons and neutrons. It is believed that they are the basis of that property of matter which we know as mass and inertia. They include some of the constituents of cosmic rays and, of course, we generate them regularly at a frequency of 10^{30} cycles per second in mass spectrographs, electron microscopes, and electronic vacuum tubes of all kinds, as well as cyclotrons and nuclear changes by atomic fission.

The next kind of cycles deals with the binding forces between the constituents of the nucleus of the atom—the kind of energy we expect the sun draws on for its enormous amount of radiation. Since the atomic bomb, much more is being published about this.

Next come electromagnetics—the radiations produced by the oscillation of charged masses. We know a lot about them because they are revealed so extensively in spectroscopic, television, radio, and ordinary electric power research. You have seen frequency correlation charts of these electromagnetic phenomena. They cover a wide range—from periods measured in terms of days and years such as magnetic disturbances due to sun spots, up to the frequencies of gamma rays.

The next distinctly different constituent of Nature gives rise to the property of elasticity embraced by thermodynamics in its broad sense. It has to do with the interatomic forces involved in compression and expansion of gases, liquids, and solids, the ring of a steel bar, the tone of a bell, the vibration of a reed, the transmission of our sound waves,

*Presented at Spring Meeting of the Instrument Society of America, Detroit, Michigan, April 4, 1946.

and the heat energy relations in chemical reactions such as the burning of fuels. The frequency responses dealt with by this science range from 10 with fifteen cyphers behind it, on down to periods measured in days.

Next we deal with that elusive property of gravity—that which takes the mass and inertia property of matter and gives us weight. It, too, is evidenced in a wide range of frequency responses, from that of a short pendulum to the changes due to tides, planetary cyclic motions, and interstellar attractions.

The next ingredient in Mother Nature is the vast array of the phenomena of life—living forces which differentiate themselves from inanimate matter by growth and reproduction cycles. Their periods range all the way from the splitting of cells in about twenty minutes, to the life cycles of mammals measured in terms of years.

The next attribute found in Nature is mental activity. This development and growth covers still longer periods and deals with longer-range problems. For example, the cycles of public attitudes on some subjects are measured in terms of many years, while your reaction time to a visual signal or a pain may range from 0.3 to 0.1 second.

Finally, we deal with the last constituent of Creation—the conscience. It hardly ever comes into play in connection with anything with a life cycle of less than a year. The welfare of a blade of grass you step on wouldn't become the subject-matter of the activity of your conscience. It deals with the long-range well-being of individuals, families, communities, nations and, in its best and most developed form, the welfare of all humanity.

Now then, the unique thing about all these distinct and separate ingredients is that they share the property of cycling. Each of them seems to follow the same fundamental relation: THE FREQUENCY IS A FUNCTION OF THE RESTORING FORCE DIVIDED BY THE INERTIA OR MASS. To control any of them, specialists in various sciences, covering this whole range of phenomena, do the same thing that you and I do when we give the baby a ride in the swing, or play with a pendulum, or fire a boiler.

To counteract a deviation, we can take various kinds of corrective action. The first, often called "integral action," is the equivalent of taking a firm hand on a swing and continually moving it under complete control of our wishes by main strength. In general this is associated with strong-arm methods. It is based on the accumulated or integrated values, or total energy content, of the system. An example is feeding the coal under a boiler proportionally to the weight of the steam produced.

The next kind of control action is that based on current value. When a thing is high you pull it back down; when it is low you pull it up. This action is used when you increase the coal feed when the steam pressure is low and decrease when it is high. This "floating action," as it is often called, is also a rather poor method of control: it always overshoots. But—it is surprising what a simple "high or low" control will do with enough friction or self-regulation in the system.

A better kind of control action operates according to the rate of change of position, flow, or velocity. This is often called "proportional position action," and it is the most effective ingredient in most power-operated control devices, on esses in general. It is the equivalent of setting the accelerator on your car according to the reading on the speedometer; or changing the rate of feed of coal by the steam-flowmeter reading or by the rate of change of the pressure.

By far the most valuable control action is based on ACCELERATION—the rate of change of velocity—the second derivative of the position or indication. It is nothing more than having the sense to catch the baby on the upswing at the point of reversal so that you can take the baby out of the swing with the least shock. It is called "derivative action." It is the most desirable if you know enough about the particular problem at hand. All the natural sciences deal with cycles of various frequencies which, if undesirable, should be understood and controlled at their inception, rather than fought with violent action after they are in full swing. "Nip it in the bud" is the thought.

So then, if you desire to control spiritual, mental, living, mechanical, elastic, electromagnetic, nuclear, or matter-wave characteristics, try and catch them at the inception of a change at the point of maximum acceleration!

Each of these control actions may be used with others, the resultant being what is called multiple action.

As a result of all this sort of fundamental work, automatic-control technology has been advancing rapidly during the past ten years. Processes are being regulated to closer limits and, in many instances, large savings in equipment and operation costs are made possible by modern accurate and responsive controls. Automatic-control equipment has become most useful and common on mechanical equipment, such as automobiles and household heating and refrigerating appliances. The application of automatic control in the chemical industries has been particularly interesting because of the many variables to be controlled.

In addition, many variations of the standard applications of automatic control are being applied daily in our plants, all for the purpose of increasing quality and purity and to eliminate waste. These include the control of temperature, fluid flow, pressure, specific gravity, hydrogen-ion concentration, gas composition and liquid level.

[EDITOR'S NOTE.—*Dr. Grebe then showed a number of lantern slides of Unusual Control Problems, each a specific industrial process control problem; and explained the applications of the "catch-them-on-the-swing" principle. He has requested that this portion of his lecture be omitted.*]

From all of these illustrations, there are two important facts we can learn. To control anything for a steady growth, to increase or decrease its amplitude or frequency, you must first be able to put yourself or your tools into harmony or resonance with that which you want to control. For example, the best way to control plant pests and bacteria is to provide desirable parasites according to the need, preferably at the point of inception. The way to win a person's confidence is to make him realize that you know and understand his problems and feel with him. To keep the boiler pressure right you need a control assembly that can act in synchronism with the changes.

Any of the specialists in vacuum tubes and the like will tell you just how to select the proper voltage, capacitance, resistance, and resonance characteristics of atoms or electric circuits to produce the desired frequency response in power, radio, light, x-ray or particle-wave phenomena. Much information has been collected on the cyclic components of our economic swings so that in time we will counteract at least the psychological components by early and complete distribution of the facts to all concerned. The general use of our modern methods of education may well eliminate the extremes of our ridiculously bad mass behavior.

The second important general observation is that all these natural forces seem to act according to the second law of thermodynamics. They tend to attain lower and lower frequencies, longer periods and longer lives. As you know, no energy is ever destroyed. It is converted to longer and longer periods, lower temperatures, higher and higher entropies. There is a natural urge on the part of everything to become of longer period. We even measure the nobility of a person and his motives by the range of his point of view. Those who are looking for their own satisfaction of the present, in matters of hours and days, generally have to be put into prisons as misfits: they are not in harmony with society. Those who have a point of view and attitude covering the current welfare of their family may make fair citizens but seldom stand out. Those who think and act in terms of larger groups and longer periods of time make good politicians, capable of changing platforms as often as politically expedient. Great business men have to keep tuned to the longer-range welfare of their industry and community. Engineers, really great statesmen, and religious leaders, can be expected to show still broader attitudes and deeper insight into the longest-range problems of mankind.

But—when you deal with a person behind the plow, at the cradle, at the counter, or in high places, who is always modest, genuinely happy and generally appreciated and an example to all, then forget all we have said about cycles and their control. That person is in tune with the Eternal!

"Hypersonic" Non-destructive Material Testing*

By H. B. SHAPER, Head of Acoustic and Instrument Engineering, Brush Development Co., Cleveland, Ohio

LOCATING flaws in solid materials is now possible by a new method in the application of supersonic waves. At present, The Brush Development Company has available a standard apparatus which will detect flaws in materials by supersonic means.

In the past, various methods of detecting flaws in different materials have been used. Some of these were destructive and, therefore, could only be used as sampling tests which would give some indication statistically of the production reliability. Obviously, this is not desirable, especially where 100% inspection is necessary, as, for example, in aircraft parts.

In the non-destructive tests, it has always been necessary to correlate the flaws in the material with specific phenomena which can be produced or measured in the material. It is reasonable to expect a simple weight measurement to suffice in the case where large air inclusions occur in solid objects. However, in most cases, flaws which are encountered and which are of the air-inclusion type are generally very small, and, when the object is irregularly shaped and not constant in weight, a simple weight measurement is not a sufficiently good correlation with the flaw.

Another method which has been used with considerable success for determining cracks and surface flaws makes use of magnetic fields where the reluctance of the paths are determined from good samples. Standardization is thus obtained, and poor samples upset a balance in the measurement system.

A third method used is the eddy-current method where high-frequency radio waves produce eddy-currents in the surface of the materials and, once again, cracks or flaws will upset the balance in a given measurement setup.

It is also possible to measure the resonant frequencies of structures. This in turn is a measurement of the density and stiffness of the material. However, it is not always possible to make resonant frequency measurements unless the sample has a simple shape. For example, wide rolled sheets have many resonances, and it would be difficult to make a reliable resonant frequency measurement.

The x-ray method is widely used and gives a reading on a film which measures the mass impedance to x-ray of the material. If there are any air inclusions, the total mass attenuation of the x-ray is decreased and a greater exposure reading is obtained in that area. The advantages of using the x-ray method are obvious and well-known. The disadvantages, however, lie in the fact that in very thick materials it is difficult to obtain good sample readings; and in those cases where the flaws are thin slits which lie perpendicular to the x-ray field, little indication is given of the slit since the variations in mass due to changes in thickness of the material itself are larger than those produced by the slits or laminations.

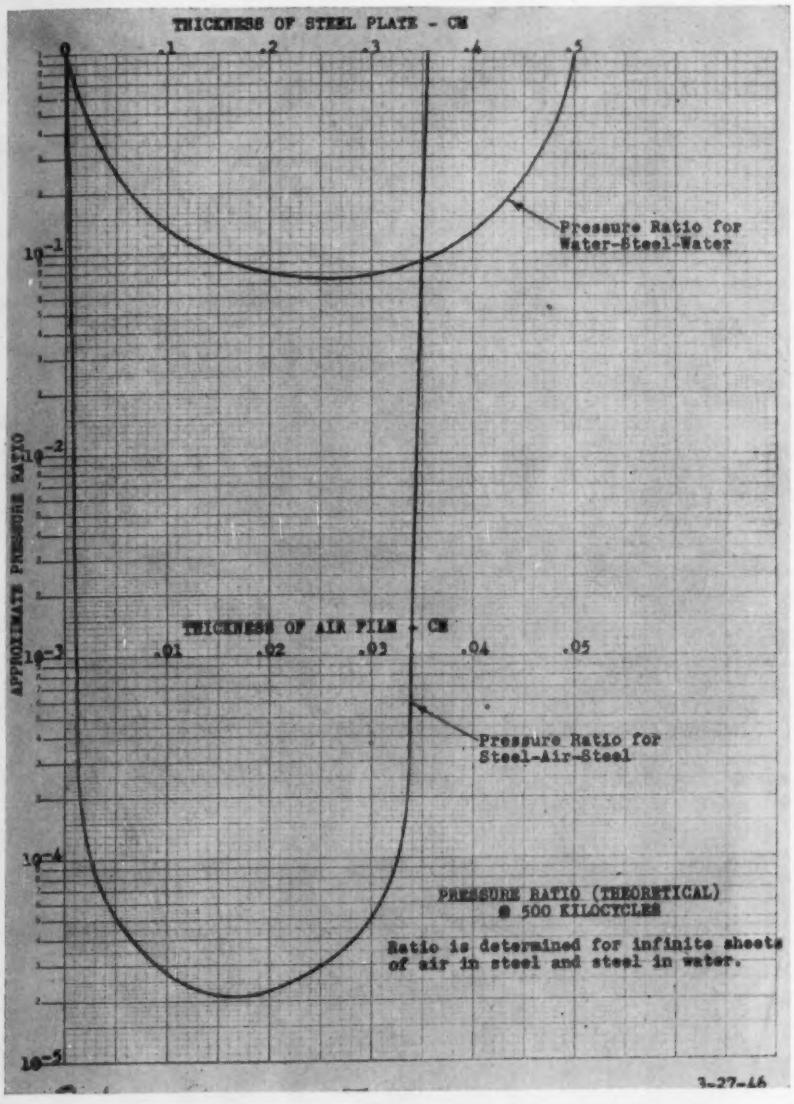

Fig. 1

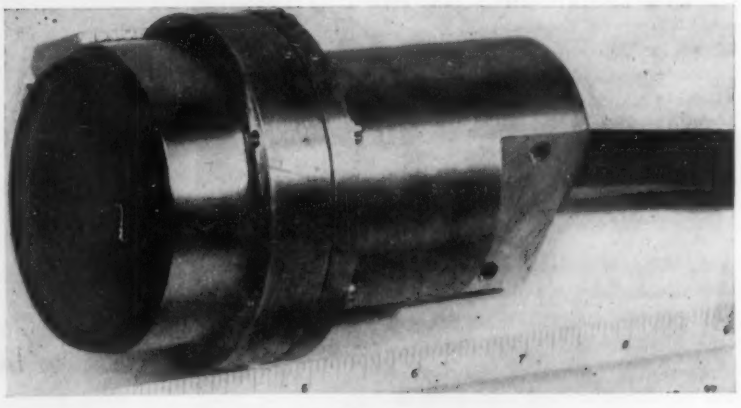

Fig. 2

*Presented at the Spring Meeting of the Instrument Society of America, Detroit, Mich., April 4, 1946.

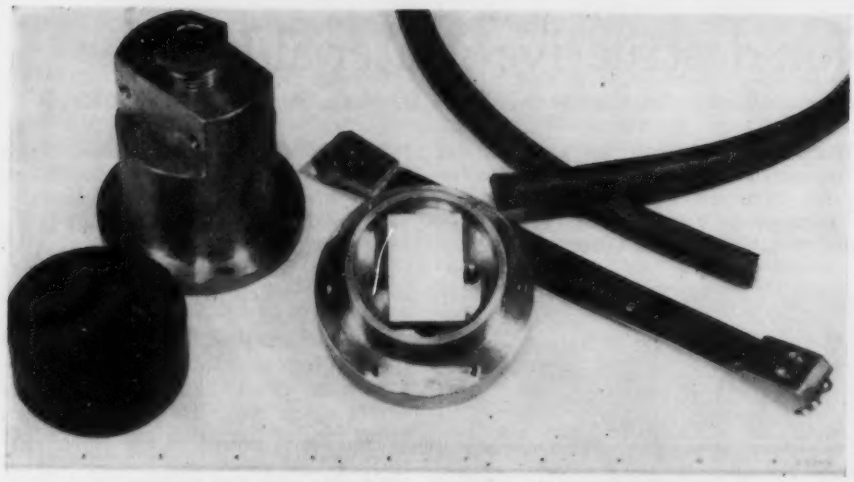

Fig. 3

The sonic methods are particularly suitable to rolled sheets where "pipes," "cat's eyes" and "laminations" occur. The sound waves are especially sensitive to flaws of the thin lamination type. Sound propagation properties of the material are a function of the density and stiffness of the material. Thus a very thin slit or lamination in the material effectively produces a violent change in the medium at the boundary of the slit or material itself. In other words, if we have a sheet of steel which has a given Young's modulus or stiffness, we can expect a large change in this stiffness property at the boundary between the steel and the air slit. The sound waves are completely reflected at this boundary layer.

The attenuation of the pressure in a sound field due to the presence of foreign objects can be calculated only in the simplest cases, and it is necessary to determine these attenuations experimentally if complicated structures are to be placed in the sound field. It is interesting, however, to set up two of the simplest cases and see how the sound pressure is attenuated:

1. The attenuation in going from steel to air to steel: namely, the case where a thin slit of air occurs in a steel medium.

2. The attenuation which occurs in the sound beam in going from water to steel to water.

This sound pressure ratio, namely the sound pressure on the far side of the slit or lamination, divided by the sound pressure on the near side of the lamination is expressed by the following formula:

$$(\text{Pressure ratio})^2 = \frac{4}{4+\{[R_1/R_2]\ [1-(R_1/R_2)^2]\ \sin\ kl\}^2}$$

where

l is the length of path in the medium.

k is 2π divided by wave-length.

R_2 is the specific acoustic resistance of the medium of the slit.

R_1 is the specific acoustic resistance of the medium of sound transmission.

If a transmitter of sound energy is directed towards a receiver of sound energy in a water medium of large physical dimensions, the microphone receiver will, of course, generate a given voltage. This voltage then establishes the pressure in the region of the microphone. If a sheet of steel of large extent is inserted perpendicularly in the sound field, it can be expected that the sound pressure will be attenuated and that the microphone voltage will be lowered. This ratio of pressure attenuation from the transmitter side of the steel sheet to the receiver side is approximately expressed in the above formula and is plotted in Fig. 1. Thus, for steel sheets in water, approximately a 10:1 attenuation in pressure can be expected for a 0.25 cm. thick sheet if a sound beam of 500 kc. is used.

If, however, the same system is set up in steel and an air slit lies between the two transducers, then as shown in Fig. 1, a slit of 0.001 cm. will introduce an attenuation of approximately 1000:1. Therefore, it is reasonable to expect that thin laminations of air in steel sheets will give much larger attenuations than the 10:1 predicted for the solid sheets of steel in water.

In practice, these sheets and slits are not infinite in extent, and, therefore, only fractional parts of the sound beam are intercepted. This in turn gives a fractional change in the attenuation predicted by these curves.

The principle of operation as described above is used in the commercial instrument to scan rolled stock as the material runs off the rolls. The material actually can travel at very high

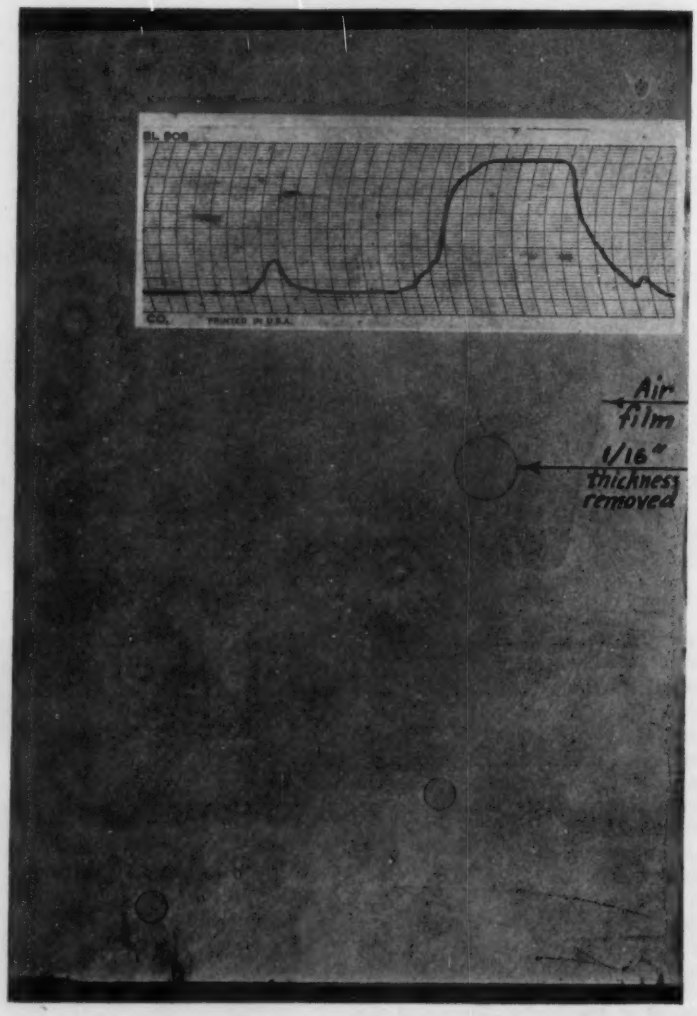

Fig. 4

speeds since the 500-kc. sound beam allows the use of high-speed marking relays. Thus, if the steel strip is running past the transducers at one-half mile per minute, only 0.05″ of material would move past the transducers before 10 cycles of the analyzing sound would indicate the transmitting properties of the medium under measurement.

This demonstrates the particular need for the high frequencies. In order to scan limited areas of material and to locate flaws within small areas, it becomes necessary to use highly directional beams which will simulate searchlights in their directionality. This in turn requires (from geometrical considerations) that the active face diameter of the transducer area be large compared to the wave-length of sound propagated in the medium. Therefore, high frequencies are necessary in order to produce highly directional beams in practical unit sizes. Fig. 2 shows a typical transducer which is used to generate 500 kc. of sound energy in water. The dimensions, as shown, are reasonable by reason of the fact that piezoelectric crystals generate these high frequencies efficiently while requiring only small physical volume.

Fig. 3 shows the same unit with its components exposed. In the center of the figure is shown a typical crystal slab, and the crystal in this particular unit is a J-cut "PN" or ammonium phosphate crystal. This crystal vibrates in its thickness direction similar to an *X*-cut quartz crystal, and thus produces a highly directional sound beam in water as is necessary to localize a given flaw. Many units of various frequencies, shapes, and sound patterns have been designed for this application, and the particular unit shown is known as AX-131.

Fig. 4 shows the hypersonic operation in a case where two sheets of Lucite were cemented together quite carefully everywhere except at a few points where a thin film of air was included in the cemented joint. In addition to the thin film and separations which occurred, some holes were end-milled 1/16″ deep in one of the Lucite sheets to insure a considerable change in the mass of the material in the area. In other words, the circular dots shown in the figure are separations where 1/16″ of material was removed from the inside face of one sheet; whereas, directly under the graph, the air film is in the order of 0.001″. The figure shows the acoustic transmission properties of this Lucite laminated sheet on a Brush BL-902 Oscillograph Recorder when the sheet was drawn past a pair of transducers which transmitted sound energy through the sheet. It will be noted that the sound transmission in the regions of flaw deviated markedly from the region of good bond. In other words, in the region of the flaw, a larger attenuation occurred in the sound field and, in the good region, very little attenuation occurred. You will note that a flaw of small area is indicated by only a small rise in the graph. This is due to the fact that the sound interception of the small flaw occurred only over a small fraction of the total area of the sound beam and thus introduced a smaller percentage of attenuation in the sound energy.

The photograph as shown in this figure was obtained by means of optical photography. In other words, a standard light source was used which beamed through the material (which was transparent material in this case) and we could have detected the flaws in this sheet optically. It is obvious, however, that if black Lucite had been used instead of the clear Lucite the optical method would have failed to disclose the flaws.

Fig. 5 shows the same sheet exposed by means of x-ray. Now you will note that only the round dots are shown; namely, the case where a considerable mass of the material had been removed. The flaws of the thin slit, however, are now not shown, as x-ray is only sensitive to change in mass of the material. Thus, in the case of black Lucite where neither x-ray nor optics would be successful in detecting this flaw, the hypersonic method still works very well.

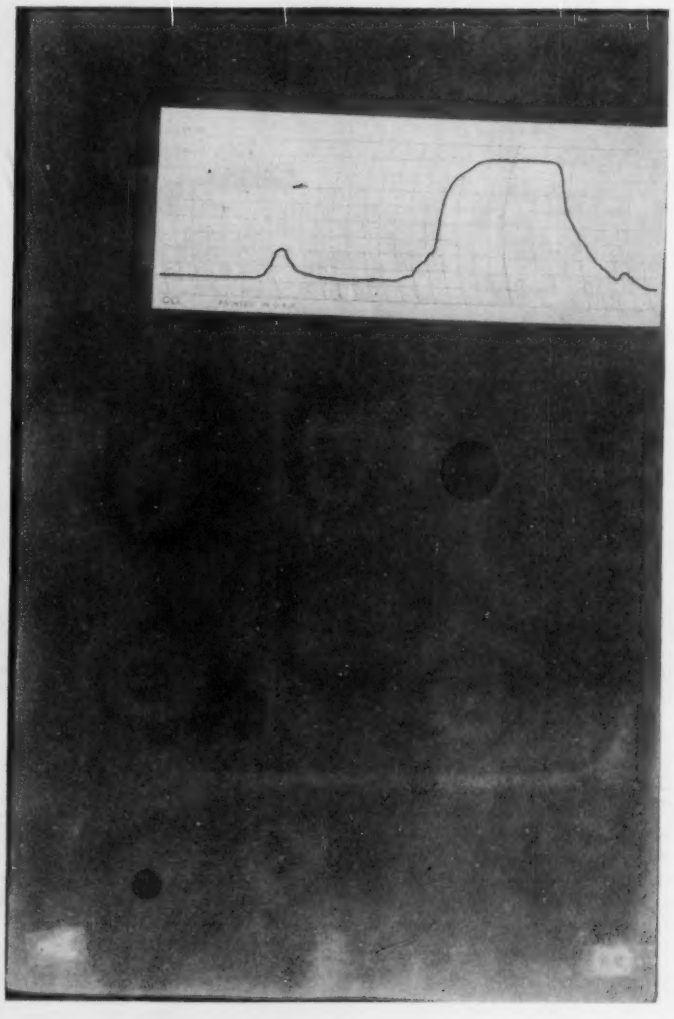

Fig. 5

Fig. 6 shows an x-ray of a typical slab of steel approximately 1/4″ thick in which there was a large "pipe" flaw. You will note that the x-ray outlines the region of flaw. This flaw is correlated accurately by means of the sound method when the sheet of steel is drawn between a pair of hypersonic transducers. The indications sonically are clear and easily read at high strip rolling speed without requirement of film or the development of negatives.

Fig. 7 shows the sidewall of a tire in which there is a separation between the fabric and the outside rubber wall. This type of separation in tires is the chief cause for blow-outs and failure in the recapping operation of tires. In this case the x-ray gives no indication of flaw and merely gives a picture of the change of contour of the outside of the tire as shown. The sonic method, however, produces very clear indications of separations in the sidewall, as shown.

Fig. 8 shows the tread of a tire in which there is a separation, and once again x-ray fails to give any indication; whereas the sonic method gives a distinct and sharp indication of flaw.

The above examples have been used merely as illustrative of the general

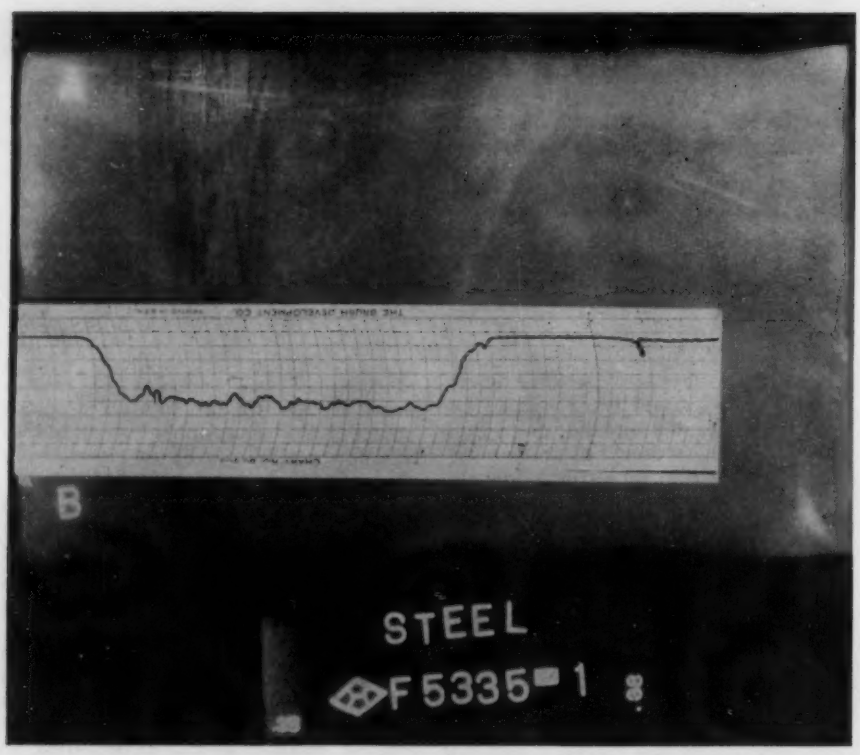

Fig. 6

principle for applying supersonic waves in the detection of flaws in materials. It is not necessary that the materials be homogeneous as shown in the case of the Lucite sheet. It is merely necessary that a good standard part be obtained and to determine its attenuation in a given sound field with a given pair of transducers. The production parts are then inserted in the sound field in an identical position and, if the reading is upset or changed, it is obvious that there must be some change in the material properties of the part.

Successful applications of supersonics to flaw detection have been made in the fields of rolled sheets, tires, knots in wood, built-up aircraft sections employing laminations, structures of wood and aluminum, plating, etc. This field is in an early stage of development. At present it is not possible to check very irregular pieces and the method is mainly used to check materials which have an axis of symmetry or which have constant cross-sectional profiles along an axis such as rolled sheets, tubing, etc., but it is likely that in the future substantial extension of the application of this method will be made.

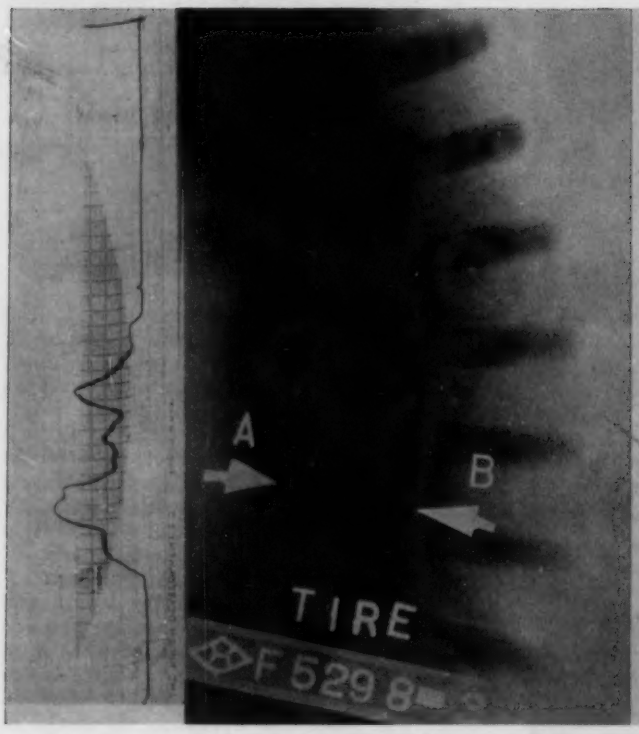

Fig. 7

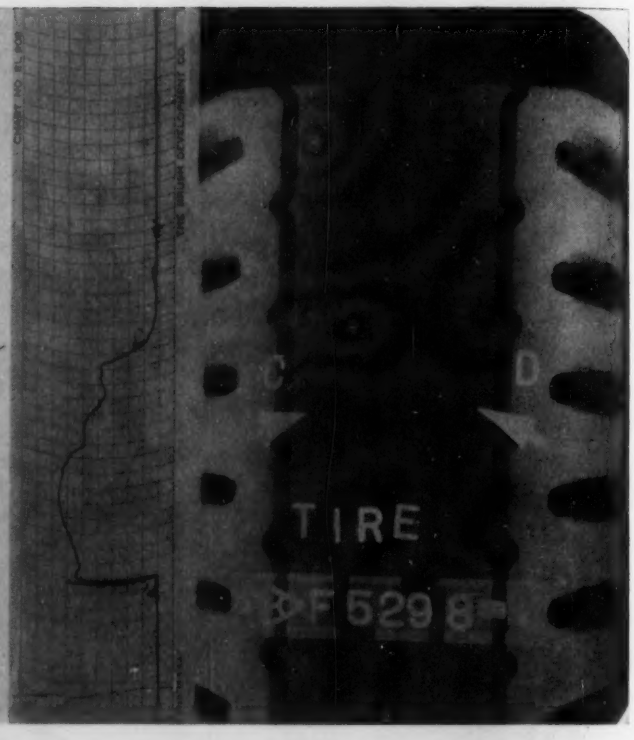

Fig. 8

Coming Next Month
(Part Two of the July Issue)

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THE 1947 INSTRUMENTS INDEX

The complete and authentic directory of instruments, for year-round buying reference, which the instrument engineer needs every day. Contains also miscellaneous information, catalog-type advertisements by the leading instrument companies, etc.

Flow-rate Metering Enters a New Technical Era*

By KERMIT FISCHER, Fischer & Porter Co., Hatboro, Penna.

WHAT would you think of a steam flow meter equipped with a recorder and integrator, giving flow rate readings in terms of pounds per hour and total flow in pounds, fully compensated for changes in calibration due to steam pressure and temperature variation, yet equipped with no pressure- or temperature-measuring elements and containing no linkage to adjust the positioning mechanism in the secondary instrument as pressure and temperature variations occurred? When we think in terms of the variable-head type meters (nozzles, Venturis, orifices) suggesting such an instrument seems preposterous. Yet if we turn to the variable-area type meter (Rotameter) and draw upon its unique engineering characteristics we find that "inherent" automatic pressure and temperature compensation without recourse to separate measuring elements can be obtained with amazing simplicity.

The method by which this is done will be described later but our question was asked in the first sentence to emphasize the opportunities for fundamental improvement and simplification which still lie ahead in the field of flow-rate measurement. Just a decade ago the variable-area meter began to elbow the variable-head meters aside in the measurement and control of process industry fluids. Yet the very fact that its rise was so meteoric tended to obscure the fact that the variable-area meter had fundamental advantages to offer in many other fields of measurement. The chemical engineers who first adopted the variable-area meter for use in the process industries did so mainly for three rather simple and obvious reasons: (1) The variable-area meter combined the functions of the sight glasses frequently needed in process lines, with the functions of a meter, thus saving a piece of equipment. (2) Complete corrosion resistance could be easily obtained since the metering tube was usually made of borosilicate glass anyway. (3) Impairment of proper operation by dirt and solids could be visually noted without breaking the piping system or shutting down. Only much later did instrument engineers recognize that many previously difficult metering problems could be solved through slightly less obvious advantages including measurement with constant and low pressure-loss regardless of flow rate change, absence of any restrictions on piping layout with bends and valves locatable wherever desired, ability to measure 20:1 ranges accurately in one instrument, uniform scale graduations, ability to measure the tiniest flows, and ability to measure without viscosity error—all of which added up to measurement with higher accuracy than previously practical. But many additional possibilities are still unrecognized, or at least unexploited. So let us return to our steam flow meter as an example of these.

To obtain the "inherent" linkless pressure and temperature compensation suggested, we make use of the fact that pressure and temperature changes affect flow rate mainly insofar as they affect fluid density. If we can make the meter operate independently of density variations, much of the problem will have been solved. We will, therefore, extend into the field of vapor measurement a variable-area meter characteristic which, applied in simpler form for liquids, made it possible during the war to measure aircraft engine fuel consumption without having to correct for gasoline density. It is necessary to review quickly the mechanism of the variable-area meter:

The downward force, equal to effective float weight, or float volume × float density minus fluid density, is in dynamic balance with the upward force, pressure drop across float × area of flow at largest periphery or:

$$V_f(\gamma_f-\gamma_w)=(P_1-P_2)A_f$$

Since head is pressure divided by density we can substitute and transpose to obtain

$$\frac{V_f(\gamma_f-\gamma_w)}{A_f\gamma_w}=h$$

since $h=v^2/2g$ by Torricelli's equation we write for fluid velocity:

*Presented at the Spring meeting of the Instrument Society of America, Detroit, Mich., April 4, 1946.

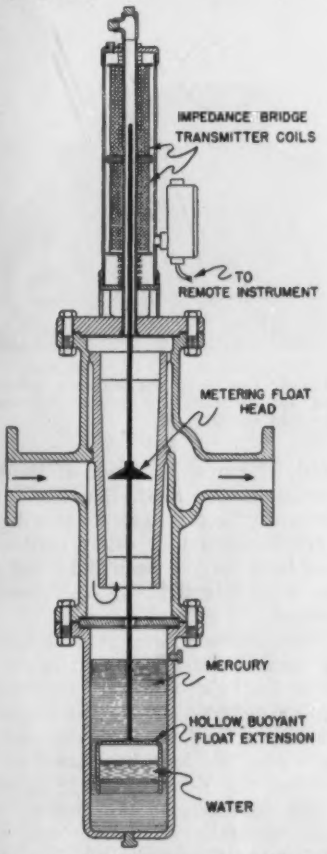


Fig. 1. Sectional diagram of a variable-area steam flow meter with "inherent" compensation for pressure and temperature changes and with electric remote transmitter.

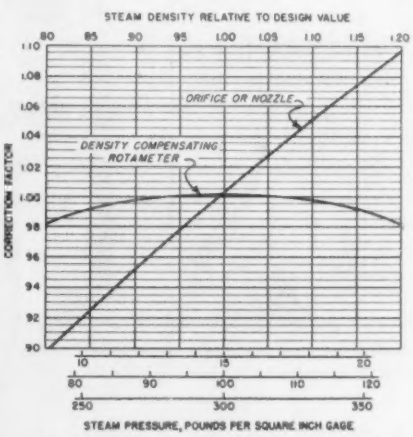

STEAM DENSITY RELATIVE TO DESIGN VALUE
CORRECTION FACTOR
ORIFICE OR NOZZLE
DENSITY COMPENSATING ROTAMETER
STEAM PRESSURE, POUNDS PER SQUARE INCH GAGE

Fig. 2. Effect of steam pressure and density changes on calibration of variable-area steam flow meter with "inherent" compensation.

Fig. 3. How a variable-area steam flow meter would appear when equipped with "inherent" density compensation and close-coupled secondary instrument.

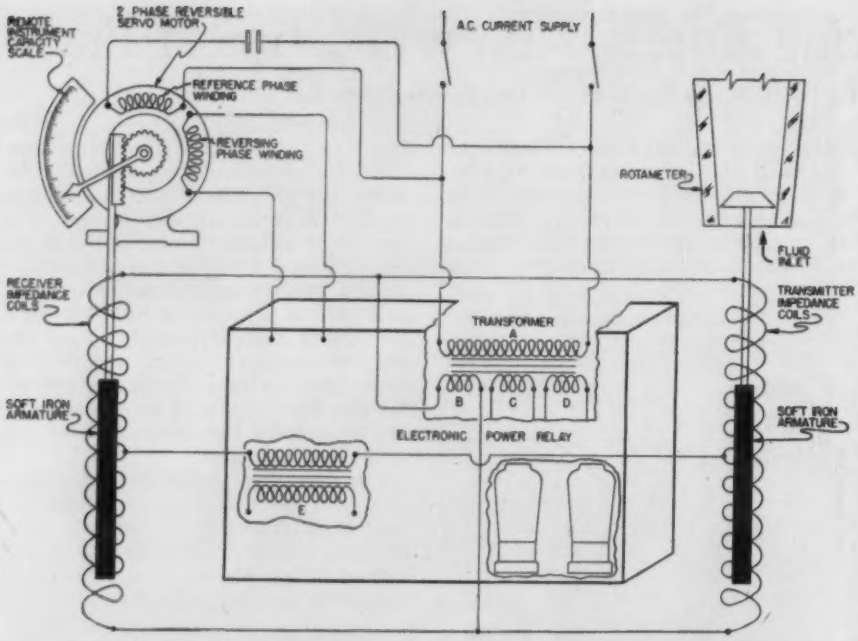


Fig. 4. Schematic wiring diagram of electronic remote transmitting system used with variable-area flow-rate meters. Details of amplifying and discriminating circuit are not shown.

$$v = \left[\frac{2g V_f (\gamma_f - \gamma_w)}{A_f \gamma_w}\right]^{1/2}$$

since volumetric flow rate is velocity times area available for flow we obtain, when efficiency coefficient C is added

$$Q = A_w C \left[\frac{2g V_f (\gamma_f - \gamma_w)}{A_f \gamma_w}\right]^{1/2}$$

Now to obtain gravimetric (weight) rate of flow we must multiply by fluid density to obtain

$$Q\gamma_w = W$$

$$= A_w C \left[\frac{2g V_f (\gamma_f - \gamma_w)(\gamma_w)}{A_f}\right]^{1/2}$$

Obviously the effect of changing float or fluid density is contained in the expression $[(\gamma_f - \gamma_w)(\gamma_w)]^{1/2}$ and we note that fluid density γ_w is contained in this expression twice, once with a positive sign and once with a negative sign. This brings up the possibility of causing the fluid density factor to cancel itself out. If we construct a graph on which fluid density γ_w as abscissa is plotted against change in calibration due to density change $[(\gamma_f - \gamma_w)(\gamma_w)]^{1/2}$ as ordinate then the slope of the curve obtained is the derivative of $[(\gamma_f - \gamma_w)(\gamma_w)]^{1/2}$ respective to γ_w. But we also know that a curve is flat and horizontal where the derivative equals zero and we find that to obtain this condition we must insert values for γ_f which are twice γ_w. Therefore: If we make the float density twice the fluid density no calibration change will be caused even by wide fluid density changes. It is not really necessary to resort to calculus to understand this. Just insert a value of 2.0 for γ_f and then vary γ_w upward and downward from 1.0 to see how nearly constant the value of $[(\gamma_f - \gamma_w)(\gamma_w)]^{1/2}$ will remain.

Fig. 5. Electronic servomotor-operated remote instrument for use with variable-area flow meters.

When metering liquids the required 2:1 ratio is easily obtained since many construction materials are available which can be combined to give a float twice the density of any industrially used liquid. However, when we are metering vapors the situation is not quite so simple. The density of stainless steel, for example, is some 13,000 times greater than the density of steam at atmospheric pressure. This problem is solved by constructing a variable-area meter as per Fig. 1. To the lower end of the metering float is attached a rod on which is hung a hollow cylinder. The cylinder is located in a well into which steam condensate drains. There it buoys up the hollow cylinder and thus reduces the effective weight of the float. Since mercury has a density about 13.5 times that of water the size of the extension well and the hollow cylinder can be greatly reduced by filling the well with mercury. This has the further advantage of offering a means for correcting the errors which otherwise would occur if the temperature in the extension well changed sufficiently to appreciably change the density of the buoying liquid. Since the density of solid metal will change only very slightly with temperature changes, whereas mercury will change more and water will change still more, it is possible to add a skirt to the bottom of the buoying extension and insert enough water in it to make the expansion coefficient of the metal float and its water equal the expansion coefficient of the mercury. Fig. 2 plots the calibration change for a typical density compensated steam flow meter as pressure changes from three mean values of 15, 100 and 300 lbs./in.^{2} gage pressure respectively. It will be seen by an inspection of this graph that the pressure regulation would have to be amazingly poor indeed to produce a significant calibration variation since a steam density variation of as much as $\pm 10\%$ from a mean value does not produce a variation of more than $\pm 0.2\%$.

It is also to be noted that the variable-area type meter when used with widely varying temperature eliminates the problem of dimensional change of the metering aperture. Whereas in the variable-head meter growth of the orifice plate or nozzle will diminish the size of the flow aperture, growth of the float head in the variable-area meter will be accompanied by corresponding growth of the metering tube which should, of course, be made of the same material as the float. See Fig. 3. No "inherently" compensated variable-area meters for steam or other vapors and gases have as yet been built but it is time that this field of usefulness be developed.

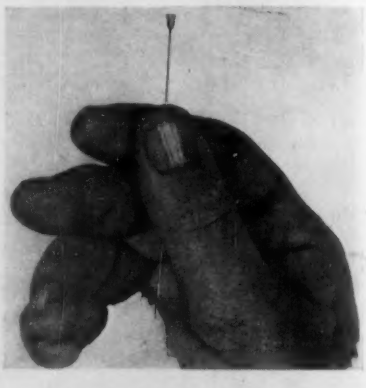


Fig. 6. Tiny float and magnetic armature used for actuating the remote instrument shown in Fig. 5.

New electronic developments open up new horizons and technical opportunities in the small-flow region where accurate automatic control has heretofore been impractical. Though the variable-area meter has long been used to indicate the "tear-drop" flows, operation of any industrially satisfactory automatic controller imposed too much force on the tiny floats which were required for low flow measurement. Now the old impedance-bridge type of trans-

mitting system has been redesigned to produce a force only one-thousandth as great as previously and has been equipped with an electronic system which detects and amplifies the current flow across the center tap of the bridge when the primary and secondary impedance coils are not in balance. See Fig. 4.

The electronic system further has the ability to discriminate between the two possible directions of the unbalance and energize the reversing phase of a two-phase servomotor so that its phase is either ahead or behind that of the reference phase winding and the motor turns in the proper direction to rebalance the bridge circuit. Standard pneumatic control systems are then operable from the secondary instrument to position small diaphragm-motor valves. Thus it is now possible to use floats which weigh less than a gram inclusive of their magnetic armature wire and to have no effective load imposed upon them by the impedance bridge circuit. This permits automatic control of flow rates as small as 10 cc./min. Note that the electronic system uses no slide-wire. See Figs. 5 and 6.

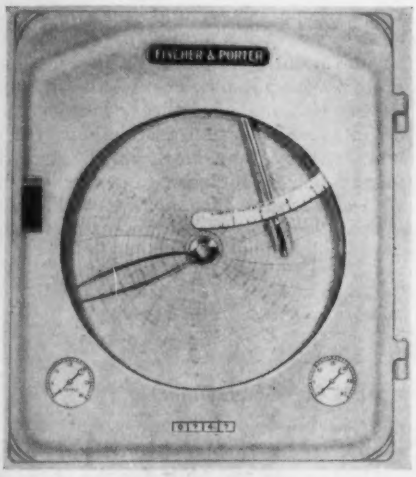
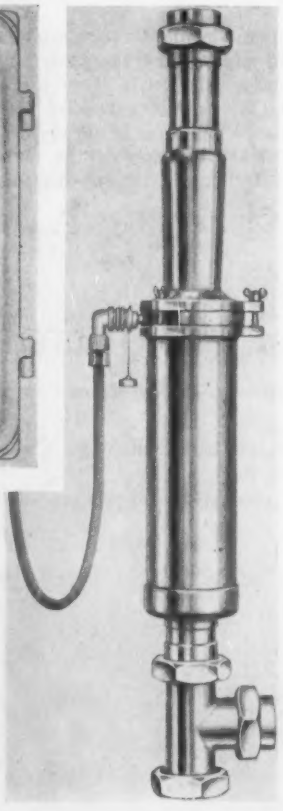


Fig. 7. Variable-area flow-rate meter designed for metering milk and other liquid food products requiring sanitary construction.



Though this electronic system was developed primarily to open up the small flow automatic control field, it has also immediately led to considerable technical advance in the field of dairy metering where previously-available equipment falls so far short of the industry's requirements that open tanks provided with level indicators are still widely used for determining flow. Now a completely sanitary variable-area meter has been developed with all parts made of, or encased in, stainless steel. See Fig. 7. A hermetically sealed stainless steel capsule located within the flow stream transmits the flow readings outside the meter body. An opening through the center of the capsule permits the magnetic armature attached to the float to travel within the magnetic field of the coils and alter their impedance. Without the reduction in size of the impedance coils and actuating armature brought about by the electronic transmitter, the bulky dimensions of the transmitting equipment would have made this new sanitary dairy meter impractical except for the very largest flows. As it is, however, many new uses will be found throughout the whole food products industry for flow-rate meters.

One of the most noticeable gaps in the roster of industrial instruments has been the absence of any instrument for measuring viscosity continuously. The need for withdrawing fluid samples from the process lines and running individual stop-watch tests in some sort of an intermittent efflux device has been a nuisance as well as an anachronism. Since the variable-area flow-rate meter has the fortuitous characteristic that it can be made either quite viscosity-sensitive or quite viscosity-immune, it becomes possible to construct an accurate continuous viscosimeter by utilizing two metering floats in one instrument. The lower float is given a viscosity-immune shape but the upper one is made highly viscosity-sensitive. Therefore, when flow is passing through the meter, the upper float will rise further than the lower one because it is lifted both by velocity head of flow and by viscous drag, whereas the lower one is lifted only by velocity head. The distance between the two floats, therefore, is a measure of viscous drag or viscosity. If an index reference line is established by raising the lower float to a position corresponding to one particular flow rate the scale above the reference line can be marked off in terms of viscosity. To take a viscosity reading it is only necessary to manipulate a valve to maintain the flow-rate momentarily at a value corresponding to the reference line flow, and then note the

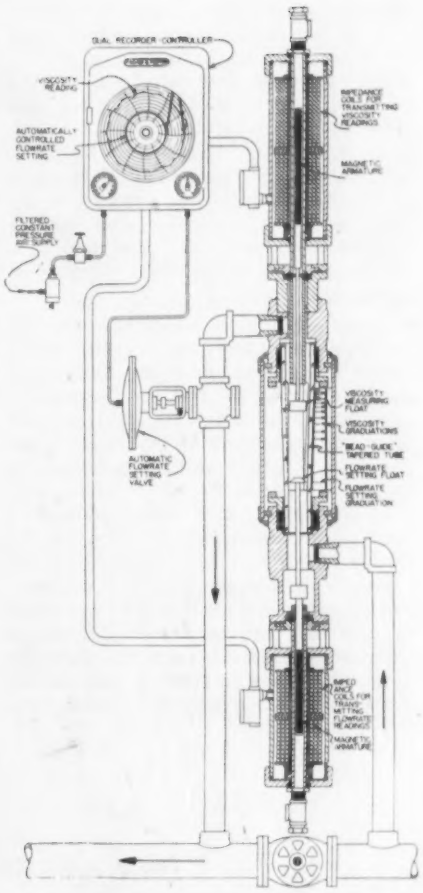


Fig. 8. Diagram of a continuous automatic viscosimeter utilizing a variable-area flow-rate meter with two floats in one metering tube.

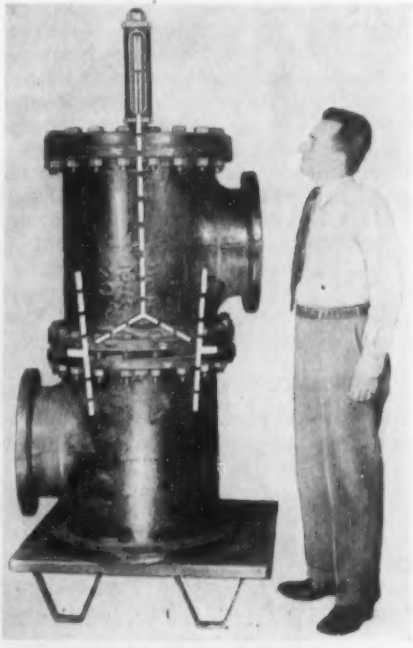


Fig. 9. A "Rotasleeve" large capacity variable-area flow-rate meter with 20" pipe connections.

position of the upper float. Of course, automatic controls can be incorporated, as shown in Fig. 8, to hold at a constant value the flow-rate in a by-pass line containing the viscosimeter and thus make it possible to obtain a continuous record of viscosity without any manipulation whatsoever. Additional automatic controls can be added to adjust the flow of steam or other heating medium or regulate the admixture of a blending agent to maintain viscosity at a constant value.

Many who have recognized how the variable-area flow-rate meter eliminated previous metering limitations have nevertheless felt that variable-area metering was restricted to pipe sizes not greater than about 6″ since the cost of larger units would increase approximately as the square of the pipe size. However, any such limitations have been practically nullified by the development of the "Rotasleeve" in which a variable-area tube is equipped with a horizontal mounting flange which is clamped between standard low-cost pipe tees obtainable from the plant fitting storeroom or from a mill supply house. Only the flanged variable area tube, the metering float and a sight extension are supplied by the instrument manufacturers. Recently the use of these Rotasleeves has extended up to 20″ pipe size, a 20″ unit being shown in Fig. 9 with the location of the metering sleeve indicated by superimposed lines.

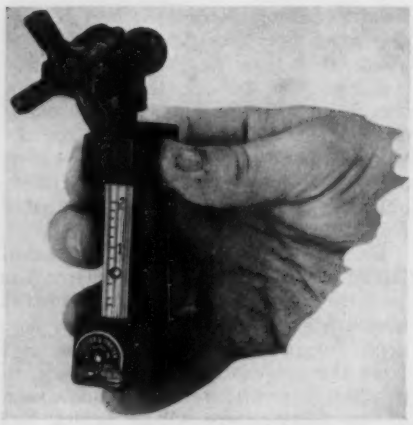


Fig. 10. The most compact variable-area flow-rate meter yet made available.

At the other extremity of size the dimensions of flow-rate meters are being reduced to new standards of compactness. The meter shown in Fig. 10 is used for such services as measuring purge line flows and air supply to pneumatic instruments in place of "sight feed bubblers." It occupies a frontal area of only 2.6 square *inches* (without the valve) on a panel board and any desired number can be nested compactly body to body along a panel on a mounting rod without the loss of any panel space between the individual units. A flow-rate meter cost which does not exceed the cost of ordinary industrial thermometers and pressure gages is thus attained with a physical size smaller than either.

These few examples of progress in flow-rate metering technology will, we hope, show that there has not been reached a period of stagnation where nothing remains to be done but determine the flow coefficients of various variations of orifices, nozzles and other fixed position restrictions. On the contrary, by a fresh approach to the problem of methods of metering, unlimited avenues into a new technical era of flow-rate measurement are opened.

Boiler Control*

By P. S. DICKEY, Chief Engineer, Bailey Meter Company, Cleveland, Ohio

AT this meeting you have heard of a number of problems which have been solved by measurement and control. I am going to discuss measurement and control for another rather involved industrial process — the steam boiler.

In the December 1943 issue of *Electrical World*, Mr. A. E. Knowlton presented a very interesting survey of opinions of power engineers regarding the post-war power plant. The following statements were made regarding the use of automatic control: "Automatic control stands in wholesome favor for the post-war plants, particularly those with variable loads" . . . "One cogent reason given for boiler controls is that large modern boilers have so small a quantity of water in them that it would be absolutely unsafe to trust the regulation to human agencies unless the plant could be operated so as to be held at reasonably constant or base loading."

Developments of the War Years

During the past few years, manufacturers of automatic control equipment have devoted much of their effort towards equipment for steam generating plants directly connected with the war. The Naval and Merchant Marine building programs called for a tremendous amount of steam power. Fig. 1 shows typical marine steam power plants having boiler control which were built during the war.

The top photograph shows one of the steam-turbine-driven cargo ships designed and built for the U. S. Maritime Commission. More than 500 ships of 4,000, 6,000 and 8,000 hp were equipped with automatic combustion and feedwater control.

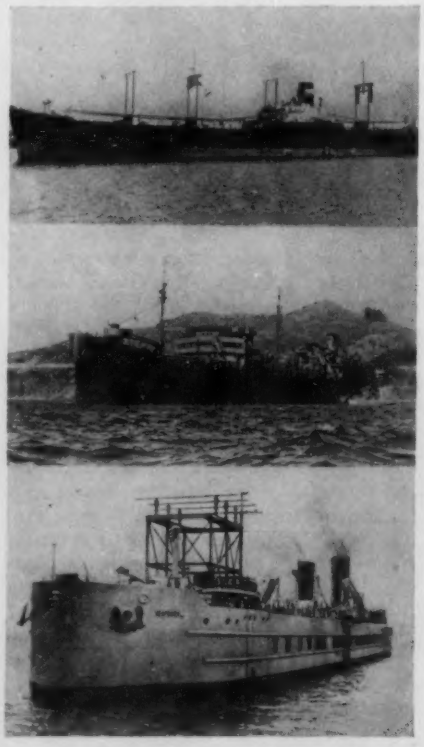


Fig. 1. Typical Marine Plants: Above, U.S.M.C. Cargo; Center, U.S.M.C. Tanker; Bottom, U. S. Army Power Barge.

The center photograph shows one of the oil tankers built during the war. These tankers were provided with steam power plants of 6,000 to 12,000 hp. Approximately 500 of these ships were equipped with automatic boiler control.

The bottom photograph shows one of the power barges built for the U. S. Army. Four barges of this type were constructed, each having steam turbo-electric generating plants of 30,000-kw. capacity. Each plant was equipped with a complete automatic boiler control system. These power barges served their purpose admirably during the war period. Not only were they used to bolster the power supply in various sections of this country but two of them were towed across the Atlantic. During the crucial winter and early summer of 1945, they supplied more than 150,000,000 kwhr. to the Belgian Power Network which was in dire need owing to a critical shortage of coal.

Recent Developments and Post-war Trends

It is our firm conviction that the use of better and more nearly complete automatic control systems will be a continuing factor in the improvement of steam generating stations. An analysis of the

*Presented at the Spring Meeting of the Instrument Society of America, Detroit, Michigan, April 4, 1946.

trend of development indicates that the success of many new designs will depend on the proper use of automatic control.

Peak Load Power Plants

Since we can expect further extension of hydro-electric power and more complex power transmission networks between generating and consuming areas, further use of steam generating plants capable of quick pick up in load is likely. Typical plants of this type are now in operation at Los Angeles,[1] Glendale, Calif.,[2] and Burbank, Calif.[3] Boilers are designed to burn oil or natural gas. These fuels permit use of a simple combustion system capable of sufficient range of operation to allow the plant to operate as a spinning reserve and to pick up immediately a load approximately equal to the maximum capacity of the plant.

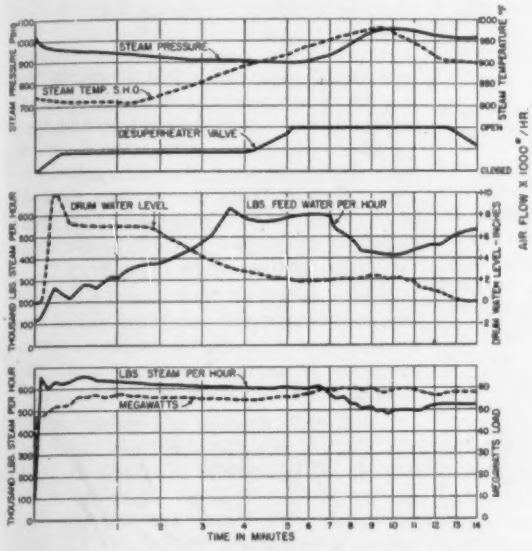


Fig. 2. Load Pick-up Test—Harbor Steam Plant.

Fig. 2 shows the performance of boilers and the boiler control system at the Harbor Steam Plant of the City of Los Angeles during a load pick-up test. It will be noted that a practically instantaneous increase from 5 to 50 megawatts was applied with an ultimate increase to 60 megawatts. Fuel rate was limited during the first 25 seconds corresponding to the time required to accelerate the combustion air supply so that a portion of the steam required was produced by reason of flashing of the water in the boiler as the steam pressure dropped. Over-firing continued for something over eight minutes to restore the boiler pressure to standard.

This over-firing caused an appreciable increase in steam temperature but the action of the two-element steam temperature control, which pre-set the desuperheat valve in accordance with load before steam temperature change, limited the temperature to safe values. While there was considerable surge in the drum water level owing to the rapid increase in steaming rate and flashing of water in the boiler, no instability of the feed control resulted, and safe water conditions were maintained throughout.

To accomplish the shortest possible pick-up time in plants of this type, automatic control is essential. It would not be practical to keep a sufficient number of operators in attendance to permit proper coördination of the various auxiliaries of the steam generator during the pick-up of load. Even with a large operating staff, pick-up time would not equal that of the automatically-controlled plant, since automatic control is ready for instantaneous action at all times.

High Pressure and High Temperature

In the Twin Branch Station of the Indiana & Michigan Electric Co., at Mishawaka, Indiana,[4] there is installed a single steam-generating unit which makes approximately half a million pounds of steam per hour at a pressure of 2500 lbs./in.^{2} and temperature of approximately 950°F. The operating record of this unit over the past few years has been satisfactory. Since the practicality of boilers and turbines for such high steam pressure and temperature conditions has been established, overall economy will be the determining factor for construction of similar units in the future.

It appears that the preferred range of steam pressure for the larger steam generating units is between 900 and 2500 lbs./in.^{2}. Steam temperatures of 900 and 950°F. have been used extensively in recent years in power generation and steam temperatures in excess of 1,000°F. have been used in process work. It is to be expected that advances in metallurgy and the competition of other forms of power production will bring higher steam temperatures in the steam plant.

The value of automatic control equipment is materially increased with high steam pressure and steam temperature conditions for the following reasons:

1. At elevated temperatures, strength and stability of materials decreases rapidly if normal temperatures are exceeded and, therefore, controls are required for safety.

2. Plants designed for operation at elevated temperature and pressure lose much efficiency if design conditions are not maintained. Therefore automatic controls are desirable to maintain efficiency and thus justify the higher plant investment.

Boilers designed for operation at high steam temperatures require means for limiting the temperature as the boiler loading increases. Methods used consist of dampers regulating the flow of gases over the superheat surface, separately-fired superheater furnaces and steam attemperators located between sections of the superheater with provisions for cooling by means of closed heaters or water spray.

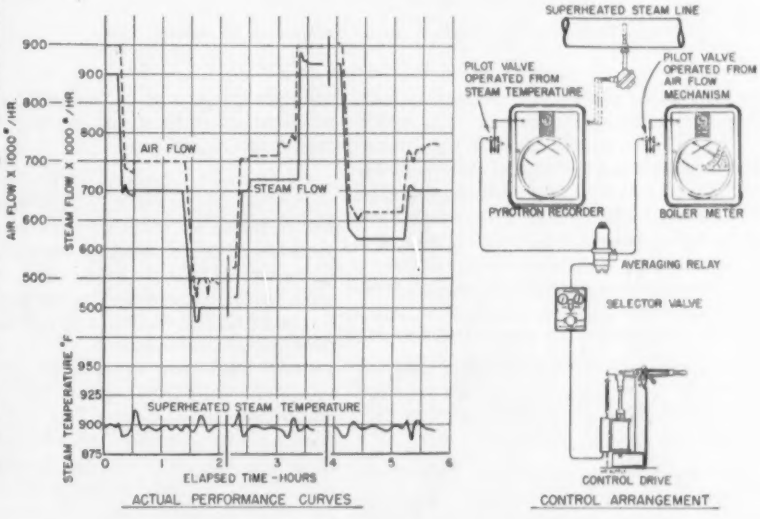


Fig. 3. Two-element Steam Temperature Control.

The multiple-element system of automatic steam temperature control shown in Fig. 3 has been very successful for these boilers. In this system, the steam-temperature-limiting means is controlled primarily from a measure of boiler load with readjustment from steam temperature. The value of such a control system is demonstrated quite clearly in Fig. 3, which shows load changes on one of the large central station boilers.

Further refinements in boiler design and continued improvement in steam temperature controlling devices can be expected as steam temperatures increase.

Combustion Improvements

Much thought and hard work has been devoted to the problem of burning solid and liquid fuels. We must continue our development toward methods of utilizing the maximum amount of available energy in the fuel and toward proper disposal of the ash without creating a public nuisance and with a minimum of outage for cleaning. Much of the improvement in burning of fuel comes from better preparation of the fuel,

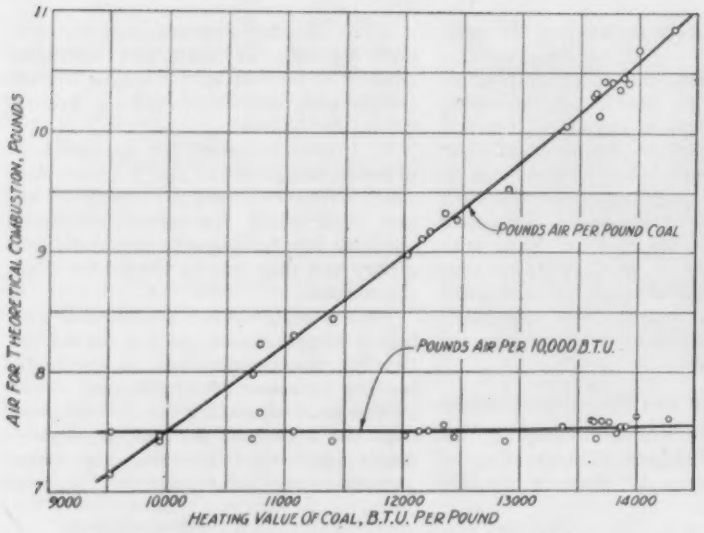


Fig. 4. Theoretical Air Required for the Combustion of Different Coals.

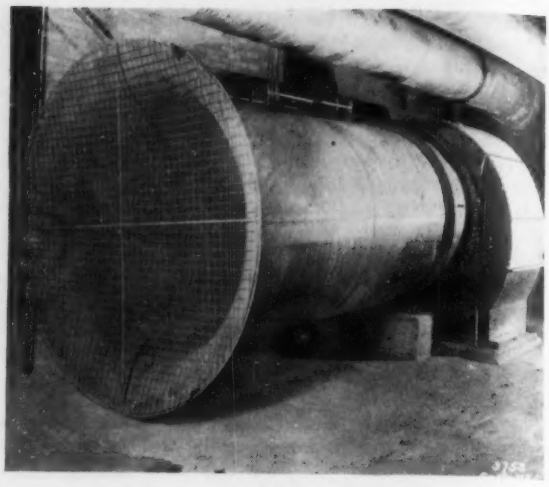


Fig. 5. Measuring Orifice for Combustion Air.

better burner design and better furnace and boiler design. However, the application of automatic-control equipment for close proportioning of the fuel-air relation and for maintaining drafts, pressures, temperatures, etc., has been and will continue to be an important factor. Designers of boilers, furnaces and burners are permitted greater freedom when operating conditions are closely maintained by automatic control.

The methods ordinarily employed for determining and controlling the relation between fuel and combustion air in steam boilers are as follows:

1. Steam Flow - Air Flow. This method has been used almost universally on boilers for the past thirty years. The scheme is made practical by the fact that the B.t.u. release per pound of combustion air for any commercial fuel from natural gas to anthracite coal is constant within 5%. Fig. 4 shows the values for coal.

B.t.u. release is determined by measurement of the steam output of the boiler. A comparison of steam output and flow of combustion air indicates combustion efficiency. Since the measuring instruments used for control are simple, sturdy and reliable, this scheme remains the most desirable basis of automatic control.

In recent years, the complexity of boiler and furnace design has introduced some complications in the steam flow - air flow method of combustion control. Measurement of the total air for combustion or of the gases resulting from combustion is very difficult in certain boiler designs. As a result a number of plants have provided suitable orifice installations similar to Fig. 5 for measurement of all combustion air at the entrance or discharge of the forced draft fans. We believe that the improvement in operation possible through close fuel-air proportioning justifies thorough consideration of the problem of accurately measuring combustion air flow. Since adequate measuring ducts take considerable space, consideration of this problem must be given during the initial stage of design.

2. Pre-measurement. Pre-measuring systems[5] for fuel-air proportioning on the basis of weight- or volume-rate of flow have been used in recent years. Quite satisfactory results are obtained with liquid or gaseous fuels where measurement of the fuel rate is not a serious problem. Determination of the weight-rate of coal flow to a furnace is more involved with the types of burning equipment used today. The problem is further complicated by variations in moisture content, analysis, and B.t.u. value of the coal. Pulverized-coal-fired furnaces probably offer the best possibility for pre-measuring control but pulverizers as used today do not maintain a pulverized coal output in accordance with the instantaneous raw coal feed and, therefore, do not adapt themselves to pre-measurement of the raw coal supply.

Efforts are being made to measure the weight rate of flow of pulverized coal in pipes where the coal is carried by a high-velocity air stream. However, the results do not yet appear to be accurate enough to justify the use of this method for accurate fuel-air proportioning.

3. Gas Analysis. Analysis of combustion gases has been used for many years to proportion the fuel flow and combustion air flow. The first problem to be overcome in making a practical combustion guide of the gas analyzer is that of devising gas-sampling methods which insure a representative gas sample regardless of stratification. In addition there is the problem of devising means of locating permanent sampling tubes in the high-temperature zones close to the furnace so that results will not be seriously affected by air leakage. Finally, there is the problem of withdrawing, conveying and cleaning a large quantity of sample gas which is necessary to make the analysis equipment sufficiently fast in operation to serve as guide for automatic control.

Equipment which determines the free oxygen content of flue gas is much more desirable than the CO_2 analyzer. For different fuels the oxygen content of the flue gas is a more accurate indication of excess air than the CO_2 indicators, as will be seen from Fig. 6.

Much progress has been made in analysis equipment, sampling tubes and sample gas cleaning systems to overcome the objectionable features of this method of combustion control.

At Calumet Station of Commonwealth Edison Company, oxygen analysis equipment is used to regulate the coal supply to the Cyclone furnace in accordance with O_2 content of the flue gases. Continuous operation of this equipment for the past year and a half has demonstrated that flue-gas sampling and analyzing equipment can be built with sufficient responsiveness and reliability for use with automatic combustion control.

We believe that the oxygen analyzer will be of greatest value as a supplement to other combustion guides on stationary steam generating units. The use of oxygen analyzers for study of stratification in large furnaces has yielded information of great value regarding fuel-burning equipment. The oxygen analyzer can be used to advantage for compensation of the steam flow - air flow meter for variation caused by different fuel characteristics or other variables.

Boiler Feed-water Regulation

As the capacity and operating pressure of steam generators increase, the trend is toward a proportionately smaller amount of water storage in order to keep the size and cost of boilers as low as possible. As a result, it has been necessary to continually improve the type of feed-water regulator used on larger units to insure smooth and safe regulation. We have finally come to recognize the fact that different types of boiler feed regulators are required

for different boiler designs if best results and the most economical equipment is desired.

Four basically different types of boiler feed-water regulators are available.

1. Single-element self-operated. This regulator, shown in Fig. 7, consists of a thermal type level-responsive device which, by hydraulic or mechanical means, provides sufficient power for positioning the feed valve in accordance with level changes. Most of these regulators use from 4" to 6" change in drum level for full action of the feed valve. Since the regulator carries a low level at high load and a high level at low load, it is necessary that the boiler drum be large enough, and that the boiler design be such, that no serious surges in water level occur, if safe regulation is to be obtained.

2. Single-element relay-operated. This type of regulator utilizes a more sensitive level-measuring device and a relay using pneumatic or hydraulic means to amplify the level indication and provide sufficient power for positioning the feed valve. The regulator usually includes a reset type level controller so that more level change can be used for full valve action and at the same time a constant level is maintained regardless of boiler rating. This regulator is suitable for medium-size boiler units operating at medium pressures.

3. Two-element relay-operated. In this type of regulator the feed valve is positioned primarily from a measure of steam flow with readjustment from boiler drum level. A pneumatic or hydraulic relay is used to provide power for actuation of the regulating valve. This regulator is suitable for medium-size boilers subject to load fluctuations of small magnitude.

4. Three-element relay-operated. This regulator, illustrated in Fig. 8, was developed to overcome the weakness of the two-element regulator described above. The regulating valve is controlled primarily from the measured relation of steam flow and water flow with readjustment of the steam flow - water flow relation from boiler drum level. Since very accurate correlation of

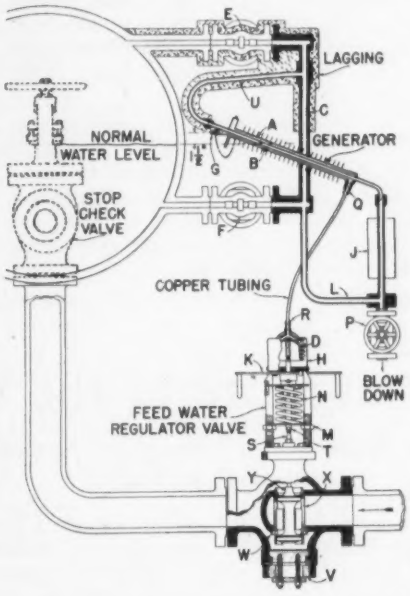


Fig. 7. Single-element Feed-water Regulator.

feed flow and steam flow is possible from the metering type flow control, only a slight readjustment from boiler drum level is necessary. The regulator is, therefore, suitable for highly-fluctuating loads and for boilers where considerable surging in drum water level is present. The use of the three-element type of control eliminates the need for accurate feed pump or excess pressure regulation. The relay type regulator and power-actuated regulating valve make the unit suitable for high pressure and high-capacity boilers. This regulator is recommended for all boilers having capacities greater than 200,000 lbs./hr. and those boiler units where high-pressure fluctuating loads or other similar feed-water regulating problems are involved.

Instruments and Control Mechanisms

We may expect continuous improvement in the instruments and controlling devices used with automatic-control systems. More extensive use of measuring instruments and automatic controls will permit more efficient production and provide the user with better devices at lower costs.

The electron tube has provided us with a new tool for measurement and control which will be very valuable in solving many of our problems. New electronic measuring devices developed during the war period are now available. While these devices will materially improve and simplify many problems, they will not supplant mechanical instruments and controllers of the type now used. We do not as yet have an electrically-operated power unit possessing the same degree of speed, simplicity, ruggedness and reliability as the pneumatic and hydraulic control systems now in use.

We should not lose sight of the fact that the quality of an automatic control system is determined not by the mechanisms alone but by the three following factors:

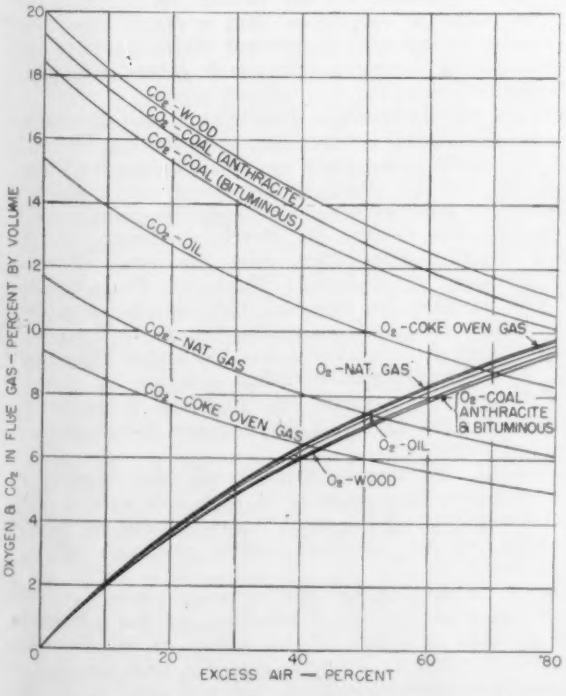

OXYGEN & CO_2 IN FLUE GAS — PERCENT BY VOLUME
EXCESS AIR — PERCENT
CO_2 - WOOD
CO_2 - COAL (ANTHRACITE)
CO_2 - COAL (BITUMINOUS)
CO_2 - OIL
CO_2 - NAT. GAS
CO_2 - COKE OVEN GAS
O_2 - COKE OVEN GAS
O_2 - NAT. GAS
O_2 - COAL ANTHRACITE & BITUMINOUS
O_2 - OIL
O_2 - WOOD

Fig. 6. Relation of O_2 and CO values to Total Air.

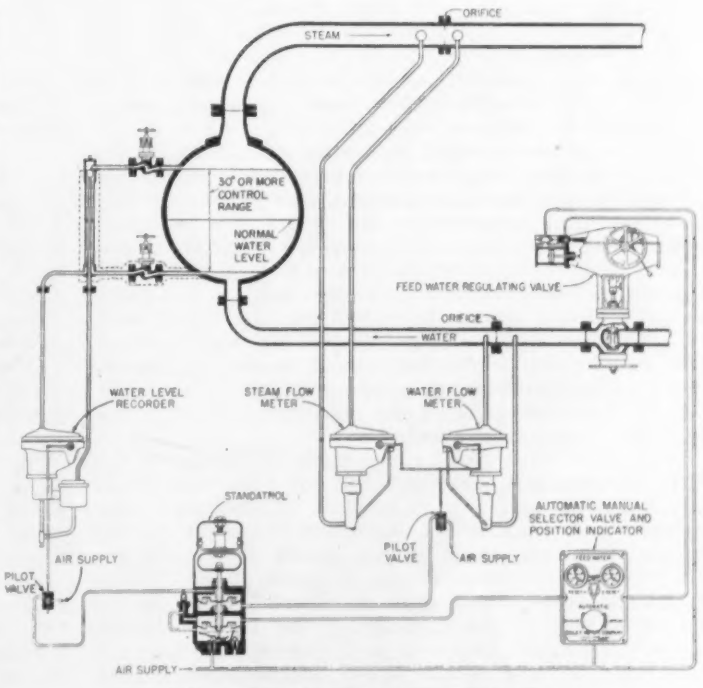


Fig. 8. Three-element Feed-water Regulator.

1. Controllability of the process. Fuel-burning equipment, pumps, blowers, etc. must be adaptable to control if satisfactory results are to be achieved.

2. Arrangement of the control system. The automatic-control system must be arranged to respond to all of the important variables in order to achieve satisfactory performance. The best of control mechanisms cannot produce the proper results if the control system is not properly arranged.

3. Control mechanisms. Control mechanisms must be rugged and suitable for continuous operation for long periods. Several basic types of mechanisms will produce the desired results on control of steam generators if conditions 1 and 2 are satisfied.

Conclusion

To summarize the thoughts expressed above:

1. The desirability of using automatic control for steam generators and auxiliaries is an established fact. Application of this equipment has passed from the experimental stage to one of refinement of equipment and methods. Designers and operators of steam plants accept automatic control to simplify and improve operation.

2. Experience gained in producing and applying automatic control to large numbers of steam plants built during the war will result in more standardized and more economical systems for small and medium-size plants built after the war.

3. Analysis of design trends of recent years points to greater use of automatic-control equipment throughout the entire steam-generating plant as a means of achieving the ultimate efficiency of the basic design with greater safety of operation.

4. More careful consideration of the control problem on the part of design engineers and manufacturers of major and auxiliary equipment will result in better performance of the complete plant. It will also reduce the length of the shake-down period often experienced from the time installation is complete until the plant is running smoothly at peak efficiency.

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"Science and Life in the World"

An Editorial on the George Westinghouse Centennial Forum

By M. F. BEHAR

IF a fiend had exploded a nuclear-fission bomb in Pittsburgh's Civic Center between Thursday morning May 16th and Saturday afternoon May 18th, humanity would have suffered a disastrous blow, for many illustrious leaders of thought in various fields of science had been brought together to a great conference on Science and Life.

Fortunately, no mishap marred the perfection of any event on the three-day program. It was if heaven had smiled upon the lofty aims of the organization that had conceived this forum, selected the themes of the sessions, named the chairmen and speakers and planned every detail down to special telephone lines and "receptionists" from high executives to pretty office workers.

This organization is the Westinghouse Educational Foundation. The forum represented hundreds of man-hours of intense preparational work on the Foundation's executive levels as well as thousands of hours of office work.

We mentioned this to one of the top-flight arrangers and he promptly shifted the credit to George Westinghouse. What better proof could anybody want of the greatness of the man whose centennial was being observed?

The Forum was arranged to provide an opportunity for scientists, engineers and scholars to correlate knowledge, advanced immeasurably in wartime, and to consider subjects for future research for the benefit of a peacetime world. Three winners of Nobel prizes took part: Dr. Archibald V. Hill, foreign secretary of the Royal Society of England who won the Nobel prize in physiology and medicine. Dr. Enrico Fermi, theoretical physicist whose work on bombardment of the atom brought him the award in 1938; and Dr. I. I. Rabi, chairman of the physics department of Columbia University, who received the award in 1944 for his application of the resonance method to the magnetic properties of atomic nuclei.

Twenty-nine other famous men made up the list of the thirty-two speakers, chairmen and toastmasters. Invitations had been sent long in advance to noted scientists, engineers and industrialists throughout the world and the "Roster of Guests," made up just before the opening, included representatives of France, England, Russia, China, Mexico and Brazil. The number of "Guests" was about six hundred—which is the capacity of the Hotel Schenley ballroom where the luncheons and dinners were held. At these luncheons and dinners it was impracticable to seat all of the thirty-two "Star Guests" as well as the Educational Foundation officials, at the head table. Therefore, at each meal, most of the "stars" sat with the rest of us "Non-star Guests."

The complete program consisted of two morning and two afternoon sessions (in the huge auditorium of the Syria Mosque), two luncheons and two dinners, lectures and demonstrations at the Buhl Planetarium, and a lecture at the Mellon Institute followed by a visit through it.

The opening session, devoted to a discussion of the subject "Science and Civilization," was chairmanned by Carnegie Tech's President, Robert E. Doherty. Nobel Prize winner A. V. Hill spoke on "Scientific Ethics" and called on scientists all over the world to "supply by our example of honesty, humility and regard for facts" the way to the establishment of ethical conduct in all international relations. He made no suggestion that scientific men feel obliged to spend their time in politics: "It is better to refrain from mixing questions of scientific ethics with political ideologies," he said.

Johns Hopkins University's President Isaiah Bowman, discussing "The Social Composition of Scientific Power," declared that world peace plans are futile unless the planners face the realities posed by the power which science and engineering have extended to "awesome dimensions." Third speaker was George W. Merck, Chairman, U. S. Biological Warfare Committee, who discussed "Peacetime Implications of Biological Warfare." Preparations against this warfare, he asserted, have led to scientific discoveries that will be of incalculable benefit to mankind.

The keynote of the Forum was sounded at the Thursday luncheon by Westinghouse President Gwilym A. Price, Marvin W. Smith, chairman, Westinghouse Educational Foundation; and Dr. L. W. Chubb, director, Westinghouse Research Laboratories.

"Instruments, techniques, theories—all developed for purposes of destruction—have given us a new wealth and a new challenge," Mr. Price said. "In return for our newfound wealth we are forced to assume new and critical responsibilities."

Dr. Chubb, in advocating speedier steps toward industrial application of scientific discoveries, pointed out that "The more rapid unfolding of the secrets of nature, the encouragement given to scientific pursuits and especially the technical accomplishments during the war, have all shown more than ever before the great influence of science

on our national welfare . . . In considering incentives and rewards for accomplishments, we should not forget the scientist and work out something to reward him for outstanding discoveries and valuable contributions which cannot be covered by patents."

The Thursday afternoon session was devoted to "The Future of Atomic Energy," with speakers including Dr. Fermi; Dr. J. Robert Oppenheimer, who planned, organized and directed the nation's special atomic laboratory at Los Alamos, N. M.; Dr. W. Edward Chamberlain, the noted biologist; and Dr. Hugh S. Taylor, Princeton University dean who discovered the most effective catalyst for producing heavy water.

"There is definitely a technical possibility that atomic power may gradually develop into one of the principal sources of useful power," said Dr. Fermi. "The chief obstacle in the way of developing atomic power will be the difficulty of organizing a large scale industrial development in an internationally safe way."

Dr. Oppenheimer reviewed suggestions already made for international control of atomic energy and expressed the belief that much might be accomplished through world government with international law applying to the citizens of nations as federal law does to those of states—an organization with safeguards against monopoly but one where controlling action could not be halted by a veto.

Dr. Taylor spoke on the chemical aspects of nuclear-fission research. Of much value, he said, are the "tracer" techniques which enable the scientist to speed up analytical processes. This will be particularly valuable in the fields of metallurgy and metallography, and also in problems of fluid flow.

Also discussing "tracer" techniques was Dr. Chamberlain, whose talk dealt with the biological phase of atomic energy.

At the Thursday dinner "Planning in Science" was the topic of a lengthy and profound address by Dr. Vannevar Bush, Director of OSRD, who was head of the U. S. wartime scientific command. He asserted that "for the good of the world and for the development of peace and plenty under the aegis of the United Nations," the balance of power among the five great world powers "must be redressed."

Developments in the transportation field and the future of the various forms of transportation were the themes of the Friday morning session. Dr. Edward Warner spoke on "Aviation"; Vice Admiral Emory S. Land discussed Marine transportation; PennRR's President Martin W. Clement discussed railroad transportation; GM's Dr. Charles F. Kettering talked on automotive transportation; and transportation planning in urban areas was discussed by Harland Bartholomew, noted civil engineer. The communications field was discussed at the Friday luncheon presided over by Major General Roger B. Colton, former director of the U. S. Signal Corps Laboratories. Dr. Frank B. Jewett, President of the National Academy of Sciences, was the main speaker.

The Friday afternoon session was devoted to the biological sciences with talks by Dr. Cornelis V. van Niel of Stanford; Dr. George W. Beadle, also of Stanford; Dr. Selman A. Waksman who discovered the "wonder drug" streptomycin; and Dr. Linus Pauling of Caltech.

The Friday dinner, chairmanned by Westinghouse Board Chairman A. W. Robertson, featured talks by Charles W. Kellogg, President, Edison Electric Institute; and MIT's President Karl T. Compton, whose topic was "Scientific Progress—Insurance Against Aggression and Depression." He declared that "both for security against aggression and security against depression there is no element which is more important than to have the most adequate possible complement of able scientific personnel in our country."

Just before going to press we obtained the following facts: average attendance at Syria Mosque sessions was 2800. About 1500 persons came from out of town (a quick study of the "Roster of Guests" shows 350 of the 600, or 60%, from out of town). Classification of the Guests: industry 30%, science 20%, research 40%, education 10%. Every word was taken down by stenotype. The complete proceedings will be issued in the form of a set of five volumes. (We recommend these books in advance of publication.)

Applications of Multiple-printing Recorders

By A. H. JORDAN and CHARLES A. VOGELSANG, Engineers, Brown Instrument Co., Philadelphia, Penna.

MULTIPLE record printing, already a fount of information in present development of new processes and for accurate information with respect to the quality of a product, is actually a gage for knowing exactly what is occurring at any one of several or at any one given point in a process.

In experimental laboratory work, engineers in the chemical and petroleum fields in particular have been able to determine the proper point for temperature measurement and to thereby obtain an optimum point of measurement. This has been especially effective in temperature measurement on fractionating columns in the refining industry. Multiple record printing has been a highly effective method of obtaining permanent and accurate records where temperature changes are more rapid and in those cases where supervisory control is highly essential for providing knowledge of what is occurring and, consequently, to provide a means of improvement and further study.

In general, then, multiple recorders are ideally suited to meet the demands of many industrial and laboratory measurements. This is particularly true in those cases where it is desirable to make comparisons between the records of related variables. See Fig. 1.

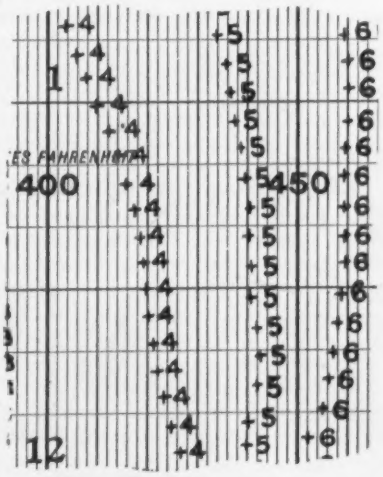


Fig 1. Actual-size chart section from multiple-recording strip-chart self-balancing potentiometer.

In this article, no attempt will be made of a multiple recorder. Description is confined to the types of multiple printing available, namely cyclic printing and synchro printing.

Several major factors must be considered in selecting the proper multiple recorder for each industrial and laboratory measurement problem. The rapidity with which variables will change will often determine how close the individual points on the record of each variable must be. It will also determine how often the printing of each variable must occur to properly follow the character of changes taking place in the variable.

The spacing between the record of the individual variables on the chart will affect the choice of the range of the instrument and also the type of the printing.

As an example, it is often an advantage to record on one chart the temperature of the total charge to a multipass furnace, the temperatures in each

furnace pass and the temperatures of the stack gases.

In the case of chemical laboratory work it may be desirable to record on one chart the pH readings of solutions in several tanks or vats employed for a research project.

In addition to centralizing correlated data on a single chart, multiple recording offers other advantages, including a reduction in costs and also space ordinarily required where several single-point instruments would be used to measure and record a group of related variables. When critical or very rapidly changing variables are concerned a single point instrument, which will continuously make a record of only one variable, will be the logical instrument for the problem or task.

In the majority of applications to which multiple printing is suited, the measured variables change reasonably slowly so that a record of each variable, made once every three minutes with a standard-speed six-record instrument, is considered satisfactory. Nothing is ordinarily gained by employing a high-speed instrument to make several records each minute since high-speed operation increases the element of instrument wear and unnecessarily consumes the chart, with consequent waste of both paper and chart filing space.

For average applications an instrument equipped with cyclic or fixed cycle printing meets most requirements. A standard-speed six-record instrument employing cyclic printing, with a print-wheel-carriage speed across full scale of 24 seconds, will print a point on each consecutive record once every 30 seconds, meaning that successive points on any given record will be printed once every three minutes. When variables change somewhat more rapidly, a fast-speed instrument employing cyclic printing but with a print-wheel-carriage speed across full scale of 12 seconds, will print points on consecutive records once every 15 seconds, so that successive points on any given record will be printed once every one and one-half minutes.

In cyclic printing, the printing cycle must be sufficiently long to permit the print-wheel carriage to travel completely across scale between the printing of points on two consecutive records. This is necessary to permit accurate recording of two variables which may be widely spaced or, in an extreme case, where the record of one variable may be at the low end of the scale while the record of the next variable is at the high end of the scale.

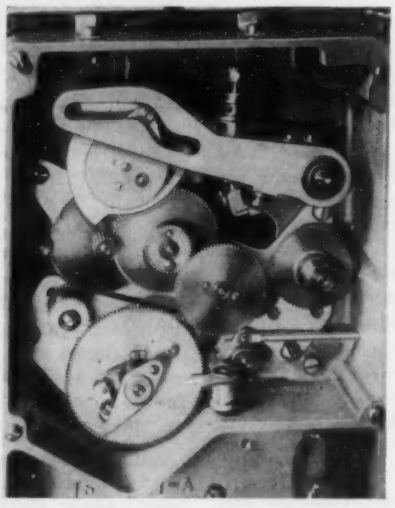


Fig. 2. End view of multiple-recording self-balancing potentiometer, partly showing the cycle printing mechanism.

It will be noted that this requirement of cyclic printing unnecessarily lengthens the interval between printing of consecutive records which may be reasonably close together yet which require a fraction of the total printing cycle for the instrument to reach a new balanced condition. This factor is important only to those applications where the time required between the printing of consecutive records is too long for the desired results.

It is possible to shorten the interval between the printing of closely-spaced records by increasing the speed of the print-wheel carriage across scale, inasmuch as the printing cycle is fixed by the maximum possible distance between records, namely, the time required for full-scale travel. Increasing the speed of the print-wheel carriage, however, increases the speed of other associated moving parts in the instrument and unnecessarily increases wear.

To speed up the printing action without increasing the speed of the print-wheel carriage, synchro printing is employed.

In *synchro printing*, action of the printing mechanism is synchronized with the motion of the print-wheel carriage so that a point will be printed promptly each time the instrument comes into balance. It is evident that the more rapidly changing variables can be accommodated with this method, since no appreciable delay in printing action occurs once the instrument is in balance. This principle, originally developed many years ago by Brown engineers for use in mechanical type potentiometers, is finding equally wide usefulness in the modern "ElectroniK" type potentiometer.

Synchro printing is available only with the fast-speed "ElectroniK" potentiometer (12 seconds across full scale) and with the high-speed "ElectroniK" potentiometer (4½ seconds across full scale), since the rapid printing action inherent in this method is not required in a standard-speed instrument.

Fast-speed instruments equipped with synchro printing have a maximum interval between the printing of two consecutive records of 14 seconds, which is the extreme case where the two records are separated by full scale width. This interval is made up of the 12 seconds required for the print-wheel carriage to travel across scale, plus a maximum of two seconds for printing to occur once balance is reached. Where consecutive records are not apart by over 30% of full scale, printing will take place once every five seconds.

High-speed instruments which are equipped with synchro printing only have a maximum interval between two consecutive records of five seconds, which occurs where the records are separated by full scale width. This interval is made up of four and one-half

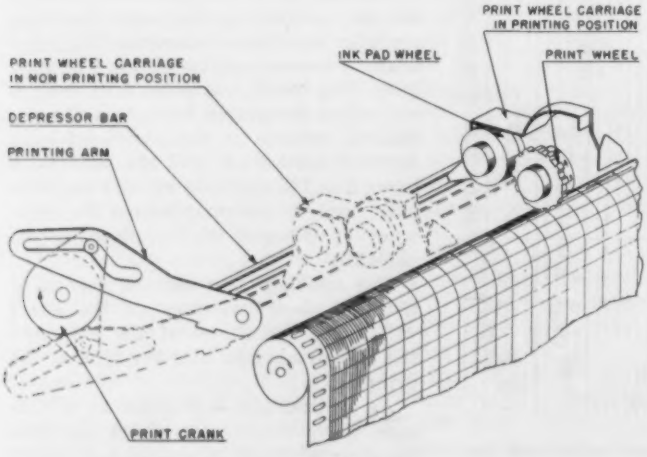


Fig. 3

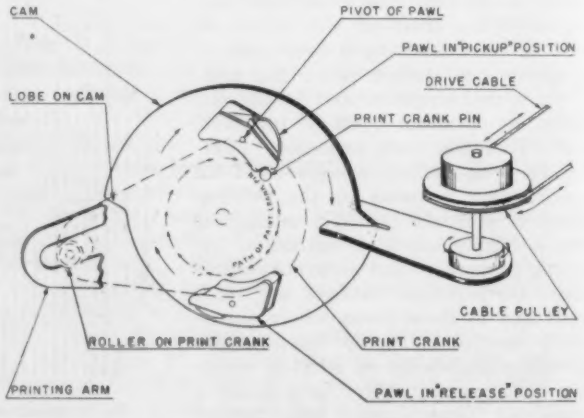


Fig. 4

seconds, necessary for the print-wheel carriage to travel across scale, plus a maximum of one-half second required for printing to occur once balance is reached. Where consecutive records are not apart by over 15 per cent of full scale, printing will take place once every second.

The *basic mechanism* employed to obtain cyclic printing, partly illustrated in Fig. 2, comprises: (1) a synchronous motor drive, (2) a print crank, (3) a printing arm, (4) a depressor bar, and (5) a print-wheel carriage which embodies the print wheel and the ink pad wheel.

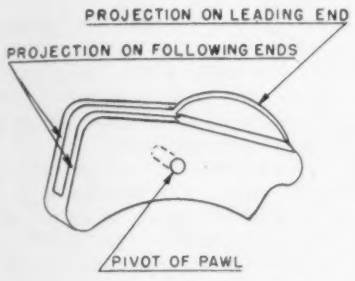


Fig. 5

The print crank is driven continuously by the synchronous motor through a suitable gear train, the time of the printing cycle being determined by the ratio of these gears. The print crank carries a small roller which rides in a slot provided in the printing arm. Rotary motion of the print crank is transformed into an oscillating motion of the printing arm. The print-wheel carriage depressor bar is actuated by the printing arm so that it moves up and down in a cyclic manner. The depressor bar is in the form of a channel to accommodate a roller on the print-wheel carriage so that the latter unit, in its motion across scale, will always be in contact with the depressor bar.

Motion of the depressor bar controls the action of the print wheel and the switching from one variable to the next. In addition to cycling the print wheel from its printing position, as shown in Fig. 3, to its inking position, (shown dotted in Fig. 3) this movement also controls the indexing of the print wheel, that is, the shifting of the printing characters or numerals in the proper sequence.

The slope of the slot in the printing arm is designed so that the print wheel will be moved comparatively slowly into engagement with the chart with sufficient force to produce pressure printing rather than hammer printing. Pressure printing possesses several advantages over hammer printing, including quieter operation and production of less wear on moving parts.

The printing mechanism just described operates continuously on a fixed cycle. In synchro printing, the design of the mechanism is generally similar in that the actions of the print crank, printing arm, depressor bar, and print wheel are identical. The synchro design differs in that a clutch is employed to engage the print crank when the instrument is balanced and to disengage the print crank when the instrument is unbalanced. Engagement or disengagement of the clutch is governed by a feeler or detector arm which recognizes when there is motion or no motion of the print wheel carriage, corresponding respectively to an out-of-balance or balanced condition.

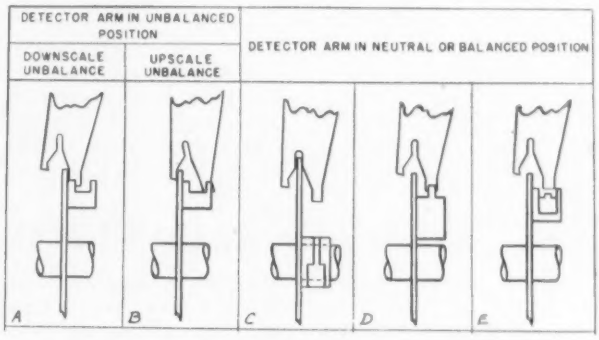


Fig. 6. (A and B) Showing projection on following end of pawl engaging tongue of detector arm; pawl is being flipped to "release" position just after instrument is unbalanced.

(C) Cam momentarily centering detector arm during unbalanced condition.

(D) Showing projection on leading end of pawl engaging tongue of detector arm. Pawl being flipped to "pickup" position just after instrument is balanced.

(E) Showing both projections on pawl clearing tongue of detector arm. Pawl is in "pickup" position since instrument is balanced.

The clutch, which is interposed between the driving gears and the print crank, is illustrated diagrammatically in Fig. 4 and essentially comprises (1) a continuous-rotating cam directly connected to the driving gears; (2) two pivoted pawls pinned to the side of the cam; and (3) a pin on the print crank.

Each pawl assumes one of two positions, namely: (1) a "pick-up" position (upper pawl in Fig. 4) in which the leading edge of the pawl engages the pin on the print crank, causing rotation of the latter member and thus causing printing action to occur, and (2) a "release" position (lower pawl in Fig. 4) in which the leading edge of the pawl clears the print crank pin, causing no rotation of the print crank and thus stopping the printing action. The path of the print crank pin is shown by the arrowed line and it is clearly seen that in release position, the pawl will clear the pin. Two pawls are employed so that in one revolution of the cam there will be two opportunities for a pawl to engage the print crank pin. The purpose of this arrangement is explained later in connection with the action of the detector arm.

Referring to Fig. 4, note that the print-wheel-carriage drive cable rides on a cable pulley, on the shaft of which is attached the detector arm. For a downscale movement of the carriage, the cable turns the pulley and the detector arm in one direction; for an upscale movement, the cable turns the pulley and the detector arm in the opposite direction. The detector arm will assume one of three positions, namely: (1) a neutral position, when the instrument is in balance, or when the arm is momentarily centered by a lobe on the rotating cam, (2) a downscale unbalance position, when the arm is pressed against one side of the rotating cam, and (3) an upscale unbalance position, when the arm is pressed against the other side of the rotating cam. Note that a V-shaped groove is formed in the detector arm and that one side of this groove is extended to form a tongue.

By referring to Fig. 5, it will be seen that each pawl is formed with a single projection midway between its edges on its leading end and with two projections adjacent the edges of the pawl on the following end. The position of the pawls on the rotating cam, whether in a pickup or release position, is governed by the relation of the tongue on the detector arm and the projections on the pawls. The relations for various stages of instrument balance and unbalance are shown in Fig. 6.

Two lobes are incorporated on the rotating cam so that twice during each revolution, the neutral detector arm will be centered momentarily. Thus, when the instrument comes to balance, one of the lobes will immediately center the detector arm and, since there will be no tendency during a balanced condition for the detector arm to move out of its center or neutral position, printing will take place almost immediately. By incorporating two pawls on the cam, the detecting mechanism is in position to feel an unbalance in one-half the time that would be required if only one lobe and one pawl were incorporated on the cam.

By employing various combinations of rotating cam speeds and by varying the number of pawls and lobes on the cam, many speeds of printing are obtained. In practice, however, it has been found that no more than a maximum of three pawls and three lobes are required.

INSTRUMENTS ON THE MARCH

Modern "Diagram Type" Control Board

[FRONT-COVER PHOTOGRAPH]

"Part of the control panel of a twin reactor Thermofor Catalytic Cracking Unit, Sun Oil Co., Marcus Hook, Pa., is pictured, showing the modern practice of representing critical sections of the unit diagrammatically on the board for the assistance of operators. On the left and right of center the respective catalytic reactors and regenerators are diagrammed with critical flows, temperatures and valve positions indicated." —J. S. CAREY, E. B. Badger & Sons Co.

New Instruments Will Speed Use of Helicopter

LOS ANGELES. — Special instruments adapted to the helicopter's peculiar flying characteristics will hasten the day when this type of aircraft becomes more generally used by the public, according to a paper presented at the Aviation Meeting of The American Society of Mechanical Engineers at the University of California here. The authors, R. G. Jewell and C. F. Savage, aeronautical instrument engineers with General Electric Co., West Lynn, Mass., in their paper on "Instrumentation for Helicopters," said:

"The instrument manufacturer must be ready with practical and efficient designs, whatever the ultimate instrument requirements of the helicopter may be: coöperating with the belief that the helicopter will not compete with fixed-wing planes, but rather that it will open up a new and still untapped field of flying—a new dimension of flight."

The authors pointed out that instruments for helicopters are in two classes: those similar to instruments used in conventional type airplanes, and those especially for the helicopter. Regarding the future of the helicopter, Messrs. Jewell and Savage stated:

"The technical 'age' of the helicopter, as compared to the highly refined airplane, is a matter of opinion. When it is considered that not more than five years have elapsed since Igor Sikorsky successfully demonstrated the VS-300, much progress has resulted—a favorable comparison to the progress of fixed-wing aircraft during the four years after the Kitty Hawk flight. Judging from the number and character of the manufacturers now actively engaged in developing the helicopter, the future of vertical-flight craft is assured. It can also be concluded that technical progress will be made at an extremely rapid rate.

"The limitations of helicopters have been the subject of much discussion. They may be listed as difficulty in control, low forward speed, relatively poor performance at high altitudes, and limitation of load and range. For example, it has been estimated that it might be as long as 1954 before the control of helicopters finally becomes sufficiently simplified to make these craft available for more general public use. Instrumentation may assist in overcoming some of these difficulties.

"The helicopter has been used very little in other than contact flying. The ability of the helicopter to stop forward motion suddenly has made it possible to do contact flying even under conditions of poor visibility. Instruments suitable for instrument flying—probably special—will be necessary if the public is to accept and use the versatile rotor-crafts to the fullest extent. Public use will require that the instruments be reasonable in cost."

INSTRUMENTS FOR JET PLANES

Another paper at the same session, presented by C. A. Edman, also an engineer with General Electric at West Lynn, dealt with "Instrumentation for Jet Propelled Planes." The development of the gas turbine as motive power for aircraft has caused a corresponding change in engine instrumentation requirements, Mr. Edman said. The flight, navigational and auxiliary instruments as yet have remained unchanged. Although good progress has been made, present gas turbine instrumentation is still inadequate, he declared. Development is especially needed in tailpipe temperature measurement, in integrating fuel-flow measurement, and in a-c. remote indicating pressure gages of the proper range.

Alloy Identification by Non-destructive Analysis

NEW YORK CITY. — A problem arose at the laboratories of Sam Tour & Co., Inc., as to the composition of a piece of metal forming a part of an intricate mechanism. The only facts known were that the material displayed magnetic properties and that there was a possibility of the existence of a metal coating. As the piece was not replaceable, it became a neat little proposition to determine its composition in a completely non-destructive manner. The surface of the piece could not be marred without ruination of its usefulness. Therefore, it could not be tested with a file nor even with a micro hardness tester. It was not permissible to etch it with an acid or to spark or arc it for spectrographic analysis.

Procedure and Results: The "Magne-Gage" work was done on three different areas of the metal piece. Rough magnetic tests were made with a relatively weak horseshoe magnet. "Magne-Gage" readings were inconclusive.

One x-ray film was made with front reflection using a glancing-incidence beam of filtered copper radiation and a 5-cm. flat cassette. The first x-ray film showed "*d*" spacings of 2.056 and 1.773. These values are closer to cobalt than to nickel and it was deemed advisable to use a more precise back-reflection method to check this.

A second film was made but with a 3-cm. cylindrical camera. Film No. 2 had a sequence of lines of a face-centered cubic structure.

A third film was made by back-reflection method, copper target, and a 4.1-cm. flat cassette. Film No. 3 calculated to a lattice constant of 3.592.

Weight and diameter measurements were checked and then coefficient of expansion was checked. A specific gravity of 8.11 was determined from weight and diameter measurements. The coefficient of expansion over the range of 80 to 180° F. was found to be approximately 1.5×10^{-6} per degree F.

Discussion & Conclusions: The nickel-iron alloy known as Invar, containing approximately 36 to 38% of nickel, has the following properties: Specific gravity, 8.12; magnetic properties similar to steel; coefficient of expansion 1.5×10^{-6} per degree F.; face-centered cubic lattice; lattice constant, 3.590.

The piece of metal was thus determined to be of Invar.

Watchmaking School for Veterans

LOS ANGELES, Calif. — Facilities of the American School of Aircraft Instruments, used to train Army enlisted men as Air Force technicians during the war, have been expanded to include a watchmaking school and converted to training veterans who aspire to become watchmakers and instrument experts, Ralph Hemphill, president, announces.

Disabled war workers, injured in industry, also are being trained under the state of California's rehabilitation system. Already nearly 100 trainees under the federal and state plans have arrived to begin a year's instruction.

The institution is believed to be the only one of its kind in the nation.

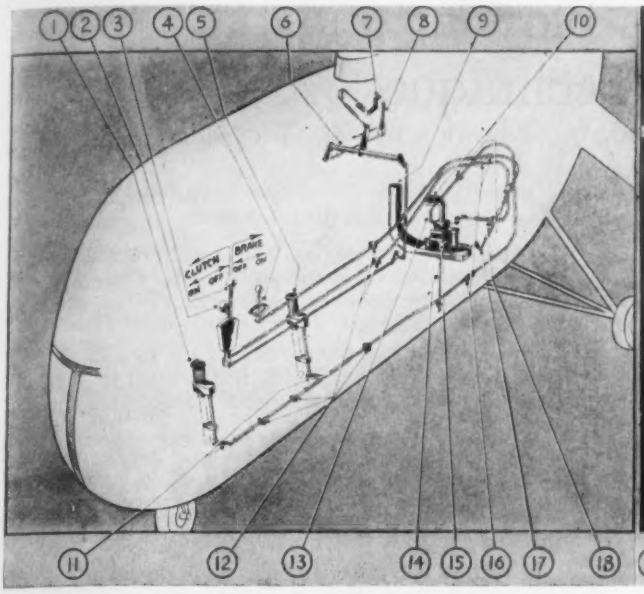


Fig. 1. Engine Control System. 1. Forward throttle; 2. Mixture control; 3. Clutch-brake lever; 4. Carburetor air control; 5. Aft throttle; 6. Clutch-brake torque tube; 7. Brake actuating lever; 8. Clutch actuating lever; 9. Cold air intake; 10. Fuel mixture to engine; 11. Throttle bell cranks; 12. Swivel fittings; 13. Throttle control arm; 14. Carburetor drain; 15. Carburetor; 16. Connector fittings; 17. Carburetor air control arm; 18. Swivel fittings.

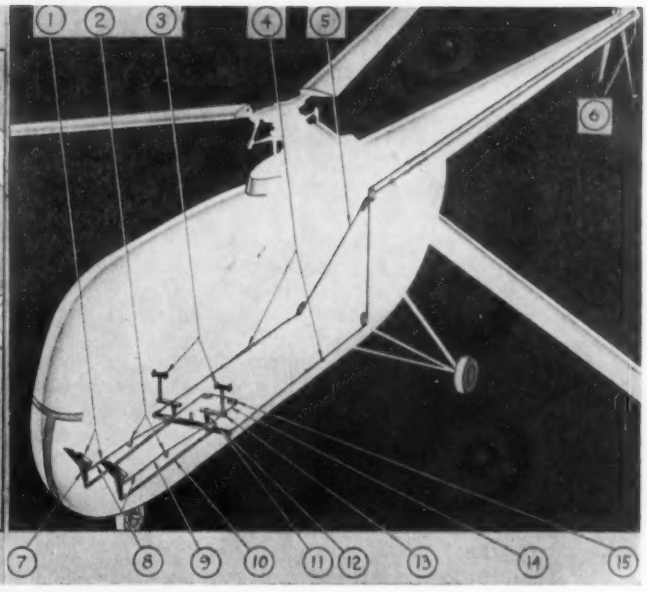


Fig. 2. Directional Surface Control System. 1. Forward pedals; 2. Intermediate idlers; 3. Aft pedals; 4. Turnbuckles; 5. Cable assembly; 6. Pitch control chain and sprockets; 7. Forward pedal arm; 8. Turnbuckles; 9. Forward cable; 10. Push-pull rod; 11. Aft pedal arm; 12. Walking beam; 13. Aft pedal Torque tube; 14. Balance cable; 15. Balance cable pulleys.

Instruments and Controls of Army Air Force's XR-9B Helicopter

AKRON, Ohio. — Some information has been released by the War Department on the XR-9B, first light-weight helicopter to meet AAF military requirements for a fast, maneuverable, easily-maintained rotary wing aircraft. It earned for itself a reputation as one of the smoothest-flying types ever tested by the Air Materiel Command, Wright Field.

It was designed and built by G & A Aircraft, Inc., Willow Grove, Penna., a wholly-owned subsidiary of The Firestone Tire & Rubber Co. G & A traces its history to the Pitcairn Autogiro Co., founded in 1929 and acquired by Firestone in May 1943.

The XR-9B and its commercial successor, the GA-45, easily can be flown hands-off the controls. The aircraft has flown faster than 100 mph; cruising speed approximates 80 mph. Service ceiling is above 10,000 feet; rate of climb is more than 1,000 fpm. The XR-9B is powered by a 135-hp. Lycoming air-cooled engine, has dual controls, tricycle landing gear. Its dimensions are: length, 27′7″, height, 8′6½″; width at landing wheels, 9′. It is one of the easiest and simplest of all helicopters to maintain and repair. Removable panels in the fuselage provide easy access to the power plant and transmission; other panels facilitate inspections and repair work.

The three illustrations herewith show for the first time the engine and directional control systems; and the instrument panel and pilot's surface controls.

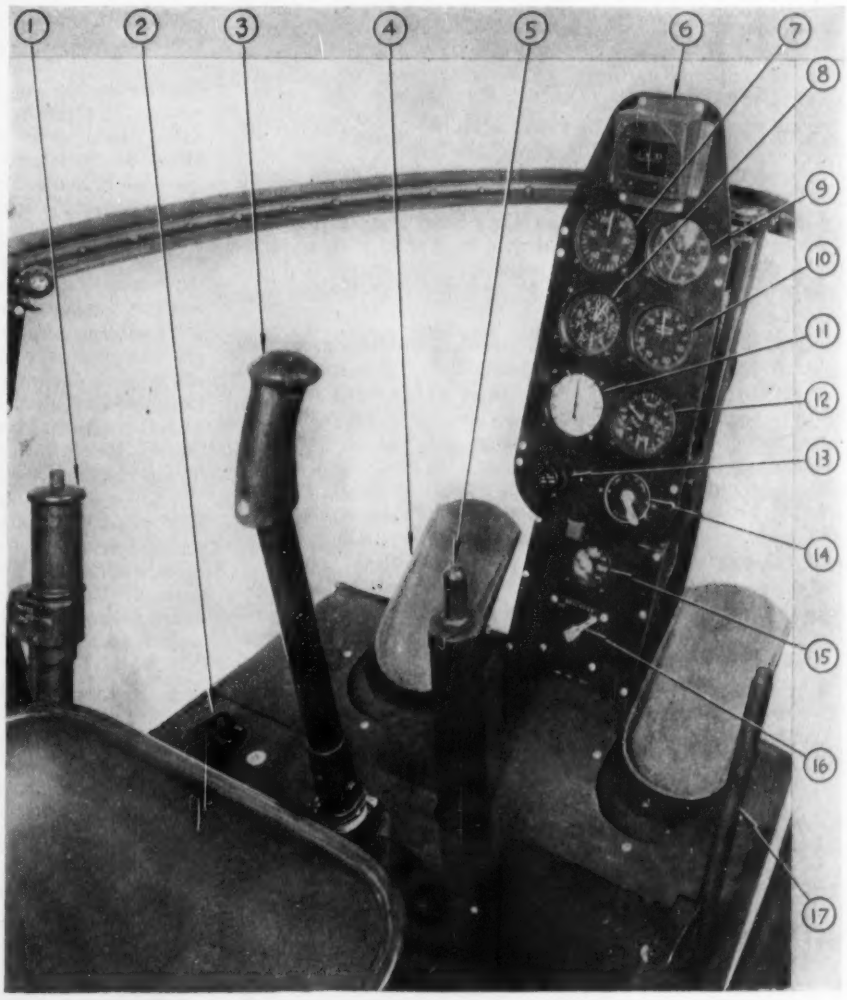


Fig. 3. Instrument Panel & Pilot's Surface Controls. 1. Simultaneous pitch control stick; 2. Fuel primer; 3. Longitudinal and lateral control stick; 4. Directional control pedals; 5. Nose wheel reservoir and strut; 6. Compass; 7. Airspeed indicator; 8. Altimeter; 9. Tachometer for rotor and engine; 10. Manifold pressure indicator; 11. Fuel quantity gage; 12. Engine gage; 13. Fuel gage pump; 14. Ignition switch; 15. Hydraulic governor pressure gage; 16. Hydraulic governor valve; 17. Parking brake.

Scientific Glass Blowing and Laboratory Techniques

By WILLIAM E. BARR and VICTOR J. ANHORN, Gulf Research & Development Company

VIII. GLASS-TO-METAL SEALS

The production of vacuum-tight seals for incandescent lamps and x-ray tubes was one of the earliest important laboratory applications of glass-to-metal seals. With the commercialization of electricity and the universal use of lamps, tubes and other electrical devices, durable seals were not only highly developed but industrialized. Considerable advances in sealing glass to metal resulted from extensive research in compounding specific glasses and metal alloys. In this connection the glass blower has been indispensable as an aid to the development engineer. Techniques in making glass-to-metal seals were developed as each metal alloy and glass was tested, and through this knowledge of handling the special metals and alloys, production machine seals have become a reality.

Platinum was among the first metals used in making glass-to-metal seals because of its resistance to oxidation and the availability of glass at that time, which yielded good seals with it. Edison's incandescent lamp in 1879 and the x-ray tubes which were produced in the United States in 1895[1] were made with platinum leads through the glass. Platinum, however, was gradually replaced by other metals and alloys for economic reasons. Although it is not used in making large-volume commercial products, platinum does have some special applications for glass-to-metal seals for laboratory uses.

A successful substitute for platinum was patented by B. E. Eldred in 1913.[2] This wire, called Dumet, consists of a copper-coated nickel steel alloy containing 38% nickel. The wire is made by fusing or welding a layer of copper, 0.054″ thick, to a round nickel alloy billet with a diameter of 0.892″. This billet is then drawn to a wire with a diameter of 0.008 to 0.015″. The thickness of the copper is about 0.00005″. This wire is still used in lamp and vacuum tube manufacture.

Manufacturers of industrial tubes adopted tungsten[3] as a metal for glass-to-metal seals in 1915. This metal was successful for seals with hard glasses which were stable to thermal shock. Molybdenum[3] was also used but with this metal special glasses were required for sealing purposes. The sealing of molybdenum to glass also required a special sealing technique because of its rapid oxidizing characteristics. Seals with both tungsten and molybdenum are still used and on occasions are quite useful in making equipment for the research laboratory.

Glass-to-copper seals were developed by W. G. Housekeeper[4] in 1923. Although copper has a different coefficient of expansion from that of glasses which have been successfully used with it, special procedures have been developed for making glass-to-copper seals. Four different types of seals were investigated:

1. Glass-to-copper seal for electrical conductors into tubes were prepared by using flattened copper wire.
2. Thin copper ribbon was sealed into glass.
3. Copper disks were sealed to glass.
4. Glass tubes were sealed to copper tubes.

A study of the iron-nickel-cobalt alloys by Howard Scott[5,6] in 1930 brought about the development of the alloy Kovar. This alloy is unique because its temperature coefficient of expansion is nearly the same as that of some glasses with which it is used for making glass-to-metal seals. Other alloys of this system were developed, as well as alloys of the chromium series. Glass-to-metal seals of these alloys were responsible for the metal radio tube which supplanted, to a certain extent, the all-glass envelope tube. The metal tube, however, is dependent upon glass-to-metal seals for insulation and vacuum-tight characteristics.

Fundamental Principles Involved in Glass-to-Metal Seals

Certain properties of the glass and metal must be known before good glass-to-metal seals can be made. The glass and metal must fulfill two primary requirements before successful seals can be realized:

1. The glass must wet the surface of the metal.
2. The stresses which are set up in the glass by thermal expansion and contraction must not exceed the tensile strength of the glass.

The first requirement may be confusing. It has been shown that the glass actually dissolves in the oxide layer which covers the metal. Hull and Burger[7] have shown that when a glass bead is placed on a metal plate which is free of oxide and both are placed in a furnace with a hydrogen atmosphere, no seal is obtained. Similar negative results were obtained with an atmosphere of an inert gas such as pure nitrogen or carbon dioxide. But when the metal is oxidized and placed into the furnace with the glass bead in an inert atmosphere, the glass forms a strong seal on the metal. It is thus important that the metal be oxidized before a seal with glass is attempted. The degree of oxidation is *very* important. If the oxide layer is too thin, the glass cannot form a strong bond with the metal and a good durable seal is not obtained. If the oxide layer is too thick, the glass cannot dissolve to the required depth in the layer and poor seals result. The success in covering the metal with a suitable oxide film is best attained by experience. Most metals and alloys are oxidized sufficiently by heating in the burner as the seal is made. Some, however, require special techniques in oxidizing the surface.

A properly annealed glass-to-metal seal will be free of strains if the glass and metal have the same coefficient of expansion over the whole temperature range—from the annealing temperature of the glass to room temperature. Unfortunately, the physical characteristics of metals and glasses over this temperature range are different. The coefficient of expansion of metals is nearly linear, while the expansion of all glasses passes through a transition point and increases more rapidly beyond temperatures of 50 to 100°C. below the lowest practical annealing temperature. These characteristics are shown in Fig. 75.[7] The curves of the three metals have higher coefficients of expansion than any practical standard glass. Pyrex glass, on the other hand, has a lower coefficient of expansion than any of the metals or alloys. The curves of some of the standard glasses show a transition as the softening point is approached. This change in expansion is not matched by any of the metals and the best that can be done is to match the glass and metal

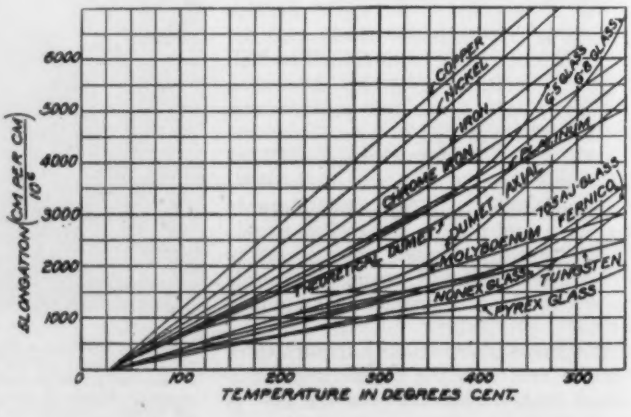


Fig. 75

curves at the annealing point and at room temperature. As an example, chrome, iron and G-8 glass have equal expansions at about 508°C. and at room temperature. A successful glass-to-metal seal could be made with this glass and alloy. Special attention should be called to the curve of the alloy Fernico.[7] It will be noted that the curve of the 705AJ glass nearly matches that of Fernico. This glass is used for sealing to Fernico or the similar alloy Kovar. Fernico is an alloy containing 54% iron, 28% nickel and 18% cobalt. Kovar contains 53.7% iron, 29% nickel, 17% cobalt and 0.3% manganese.

The physical properties of a number of glasses are given in Table 11. The Corning Glass Works code and laboratory numbers for each glass are given and the respective metal or alloy recommended for each is listed. Pyrex glass Number 774 is in the table but no metal is recommended for seals. This is borne out by the expansion curve of Pyrex in Fig. 75. Since most laboratory equipment is made of Pyrex, it is necessary to use a graded seal between the glass sealed to the metal and Pyrex. A sealing glass series for the graded seal is given in Table 3. Recommended European glasses for various metals are given in Table 12.[8]

The metal or alloy must be gas-free before good glass-to-metal seals can be obtained. Some metals require no preliminary degassing because they are freed from gas during the heating period just prior to sealing. Small amounts of carbon in alloys as Kovar must be removed and these alloys

TABLE 11
PHYSICAL PROPERTIES OF GLASS

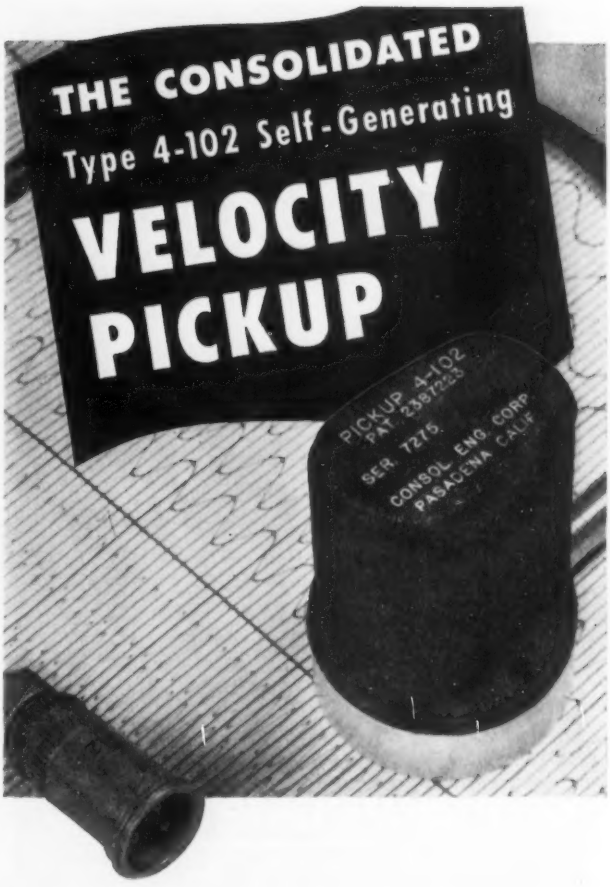
Corning Code	Glass Lab.	Temperature Coefficient of Expansion $\times 10^7$	Softening Point, °C.	Annealing Point °C.	Strain Point °C.	Sealing Metal
001	G1	91	626	428	397	Sylvania #4 Driver Harris #14 Platinum
008	G8	92	696	510	475	Sylvania #4 Platinum
011	G164HC	128	612	448	423	Iron SAE-1010
012	G12	89	630	433	400	Platinum Sylvania #4
024	G125BB	96	607	425	397	Sealmet #28 Driver Harris
778	GT70	37	763	498	464	Tungsten
3320	G371BN	40	784	535	497	Tungsten
704	G705BA	47	697	484	450	Kovar & Fernico
7052	G705FN	47	708	480	442	Kovar & Fernico Molybdenum
706	G705AO	50	690	495	463	Molybdenum Kovar & Fernico
752	G750AJ	61	747	566	530	Kovar & Fernico Does not match molybdenum
753	G805F	71	728	557	528	No metal to match
755	G805G	79	716	546	516	No metal to match
756	G705A1	86	702	536	503	Platinum
772	G702P	36	755	518	484	Tungsten
775	G705R	41	704	467	431	Tungsten
8160	814KW	91	627	433	399	Sylvania #4 Driver Harris #14 Platinum
774	726MX	32-33	819	553	510	
Fused Quartz		5.8	-	1120	1020	

are conveniently degassed by heating them in a furnace at 1050°C. for 20 minutes and in a stream of hydrogen which bubbles through a water trap before it enters the furnace. The furnace is fitted with a cooling section which is used to cool the metal to 300°C. in a hydrogen stream to prevent oxidation when it is taken from the furnace.

In the discussion thus far, an attempt has been made to introduce a few of the fundamental principles in making glass-to-metal seals. Specific examples were cited to explain and describe some of these principles. The individual metals and alloys will be taken up in detail and the techniques in making suitable seals will be described.

Platinum

Platinum has an approximate linear temperature coefficient of 9×10^{-6} per degree Centigrade; and when used in making glass-to-metal seals, a glass should be chosen with



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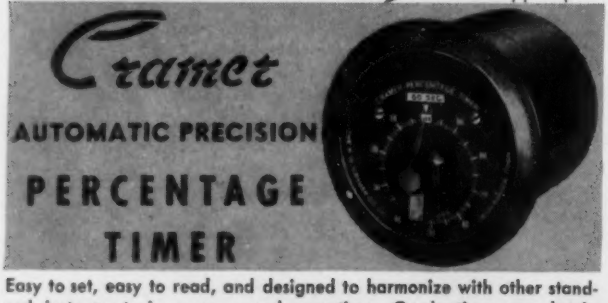

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approximately this expansion. Inspection of Table 11 will show that glass with Corning glass codes of 001, 008, 012, 756 and 8160 can be used in making seals with platinum. It was generally believed that glass-to-platinum seals were successful because this metal did not oxidize, but it has been proved that platinum has an exceptionally thin stable layer of oxide.

Platinum is usually used in wire form when it is sealed to glass. The wire must first be beaded with a suitable glass. This is done in one of two ways:

1. The simpler method is illustrated in Fig. 76. The wire is clamped in a pin vise which has an asbestos handle. A

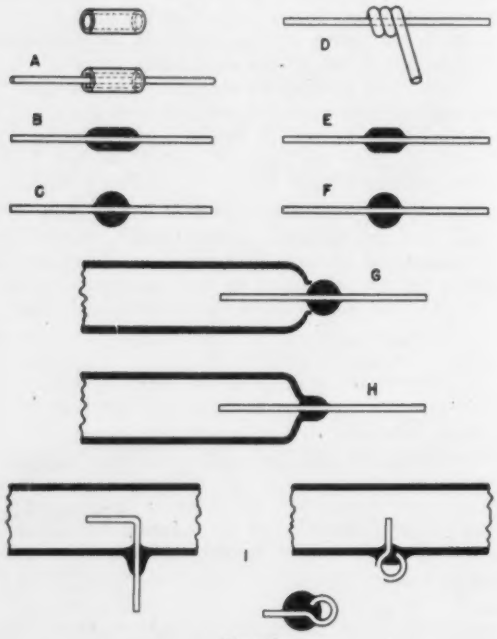

Fig. 76

small glass sleeve of about 2 mm. I.D. and 10 mm. long is then formed by fusing a 7-mm. tube, allowing it to collapse to thicken the wall and then drawing it out. The suitable size is then cut from this drawn tube. The small section is then slipped over the wire, Fig. 76A. The glass is fused at one end and after a good seal is obtained around the circumference of the wire at this end, the glass is then progressively fused toward the other end. One must be careful that no air pockets are trapped in the seal. The elongated bead (Fig. 76B) is then heated until it is fused. Surface tension of the fused glass will cause it to flow until a round bead is formed, Fig. 76C. The wire with the spherical bead is then ready to be sealed into the glass tube. The bead should not be over 4 mm. in diameter. The temperature of the bead is maintained by placing it on the screen of the Argand burner. This allows time for preparing an opening in the glass tube without the risk of cracking the bead by cooling and reheating it for the final seal.

2. The second procedure in making a bead on a wire is to fuse one end of a thin glass rod to the wire, Fig. 76D. The rod is heated until soft and wound around the wire until sufficient glass is accumulated. The rod is then cut with the flame. The coil is fused by starting at one end by heating the glass while the wire is turned slowly, Fig. 76E. Again one should be careful not to trap any air bubbles in the glass during the fusing process. It is then fused together until the glass forms a round bead, Fig. 76F.

If the wire and bead are to be sealed into the end of a tube, an end is prepared as previously described and an opening is made by blowing out a small circular portion of glass which is fused by holding the very tip of the closed tube in the flame while the tube is rotated, Fig. 76G. The hole should be slightly smaller than the bead. The hot bead and wire are then held over the hole and the former is sealed to the tube, Fig. 76H. The procedure in making side

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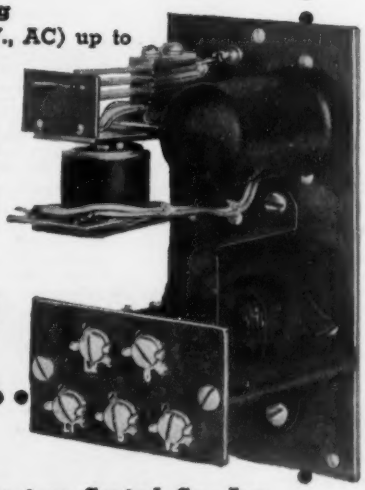

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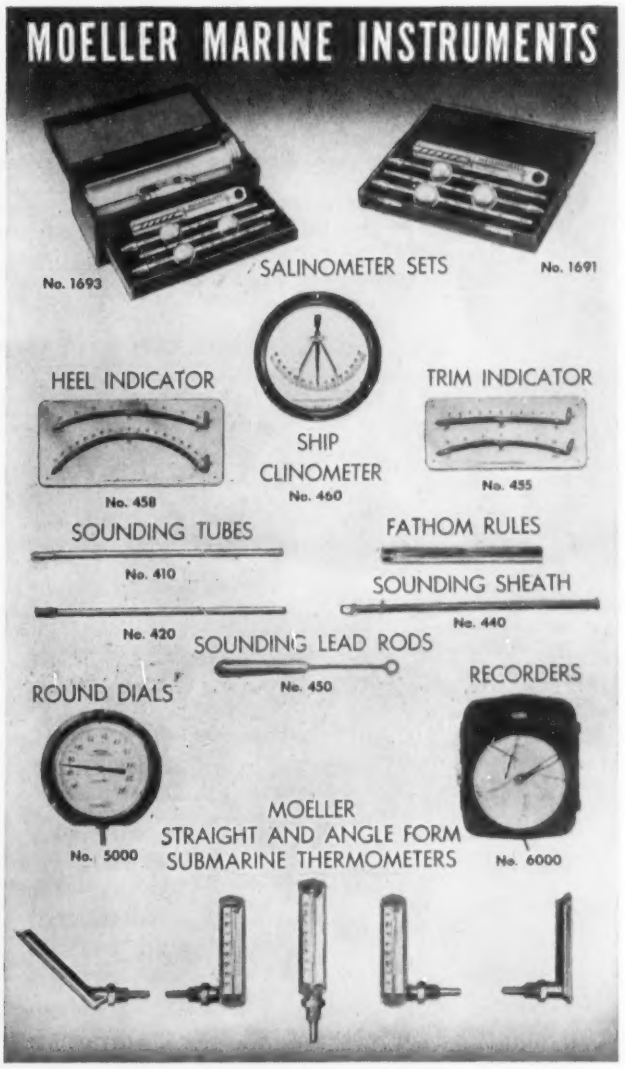

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seals in tubing is the same as given above. Two such types are illustrated in Fig. 76I.

The complete area of the seal must be carefully annealed. This annealing procedure requires a careful technique as well as judgment on the part of the worker, as it is not only necessary to heat the seal uniformly, but to avoid undue softening, otherwise the glass bead and wire will sag under its own weight.

The composition of 001 or G-1 in Table 13[9] shows that this glass contains 20.22% lead oxide (PbO). Extreme care should be exercised in the adjustment of the air-gas flame required for working the glass. The flame should be as near neutral as possible, since a reducing flame will blacken the glass and an oxidizing flame will turn the glass surface gray.

Pyrex-to-platinum seals can be made by the procedure outlined by Housekeeper for making glass-to-metal seals. Platinum electrodes can be sealed into Pyrex and successful seals can be obtained if a platinum wire 0.010" in diameter is flattened very thin (0.005") and the edges are filled to a v-shape. The thin strip is beaded as previously described except that the glass should be pressed against the platinum strip with a forceps to insure good contact with the metal. The beaded metal strip is then sealed into the

TABLE 12

INDUSTRIAL METALS FOR VACUUM TIGHT GLASS TO METAL SEALS

Metal	Commercial Form	Coefficient of Expansion $\times 10^7$	Thermal Conductivity cal./(cm.) (sec.) (deg.C.)	Resistivity ohms/ mm.^{2}/m.	SEALING GLASS
Platinum Technical to Pure	Round wire to 1.5 mm. Ring to about 50 mm. Wall thickness 0.1 to 0.15 mm.	90.2 (25-100°C.)	0.167	0.108	M-glass (Osram) 301b (Osram) Apparatus glass 301b (Osram)[1] PT-glass 16[III] (Schott) PT-glass GeGe Eff (Fischer) PT-glass (Gundelach) Apparatus glass (Gundelach) Moosbrunner glass[2] G1, G5 Glass (Corning)
Ferro Nickel Vacuum fused (a) Ni 47.5% Fe 50% Cr 1% Mn 1%	Round wire to 5 mm. Rings and caps to 30 mm.	89	0.038	0.45	
(b) Sintered ("Ommet" Ni 48% Fe 52% C<0.01%) Ni 48% Fe 52% Co 0.15%	Round wire to 5 mm.	90	0.038	0.45	
Platinum Covered Wire (Core: Ni 48% Fe 51% Platinum covering 30 to 40% of total wt.)	Round wire to 3 mm.	90	-	-	
Copper Covered Wire (Core: Ni 42% Fe 58% Copper covering: 20 to 30% of total wt.)	Round wire 0.2 to 0.8 mm. put on with borax	Radial 80-100	0.4	0.04 0.06	As above M-Glass (Osram) best
Chrome iron Cr 25-30%	Wire 2-3 mm. rods 5-12 mm. disks and rings 0.2-1.0 mm. in wall thickness	95-100 (20-100°C.)	0.05	0.5	GeGe 28 (Fischer)[4] Apparatus glass (Gundelach) G1, G5, G6 and G8 Glass (Corning)
EMK (Fe 71% Mo 10% Co 19% Si 0.8% Mn 0.0)	Rods: 0.5-12 mm. Rings: to 30 mm. Wall thickness about 1 mm.	90-95	0.05	0.33 0.37	Pt Glass (Fischer) M Glass (Osram) Apparatus glass (Gundelach)
Fernichrom (Fe 37% Ni 30% Co 25% Cr 8%)	Wire, rings	92	-	-	G5 Glass (Corning) Lead glasses
Wonico (W 80% Ni 13% Co 5%	Wire	55	-	0.13	Sodium glass V 612e (Osram)
Tungsten	Wire and rods	40-45 (20-100°C.)	0.38	0.06	V 362A (Osram) V 619i (Osram) Uranium,[4] Nonex[3] (Corning) Duranglass (Schott)
Molybdenum	Rods to 5 mm. and over	53-55 (25-100°)	0.35	0.06	1447 III, Uvioglass (Schott) V637B, V195c (Osram) G 71 or G 705 AO (Corning)
Kovar, Fernico (Ni 28-29% Co 17-18% C<0.1 Mn 0.2 Balance Fe	Wire and Rods to 16 mm. Rings 4-30 mm. wall thickness 0.3 to 3 mm.	47 (25-450°C.) 56 (25-500°C.)	0.09	0.27	V 756 (Osram) Clear sealing G 705 AG (Corning)[5] Special glass 184[6] G 71, G 705AO (Corning)
Copper Vacuum fused with 1-2% Mn or Electrolytic Copper	Feather edge rings and caps 15-120 mm. Wall thickness at fusion point 0.2-0.1 mm.	165 (0-100)	0.92	0.017	Apparatus glass (Gundelach) Pt glass (Fischer) Blue cobalt glass KHE (Gundelach), G1, G8, G71 Pyrex Glass (Corning)
Chrom Nickel Cr 21% Ni 76.5% Fe 2.3	Feather edge rings and caps; wall thickness at cap edge 0.05 mm.	145	0.03	1.09	Apparatus glass (Gundelach) Pt glass (Fischer) Blue cobalt glass KHE (Gundelach) G1, G8, G71 Pyrex Glass (Corning)

1. Composition: SiO_2 68.5% Al_2O_3 3.2% CaO 7.1 N_2O 14.2% K_2O 6.8
2. Composition: SiO_2 70.5% BaO 2.5% CaO 5.5 Na_2O 16.6 K_2O 1.0 Mg 3.9%
3. Composition: SiO_2 73% B_2O_3 16.5% PbO 6.0% Na_2O and K_2O 4.5
4. Composition: SiO_2 76.1 B_2O_3 16.0% Al_2O_3 1.75 CaO 0.2% Na_2O 5.4% K_2O 0.6%
5. Composition: SiO_2 67% B_2O_3 22.0% Al_2O_3 2.0 K_2O and Na_2O 6.5%
6. Composition: SiO_2 65% B_2O_3 23.0% Na_2O 7% Al_2O_3 5%

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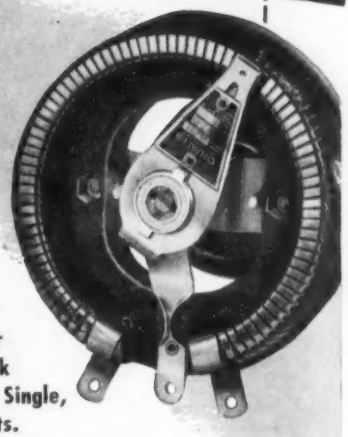

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TABLE 13
PROPERTIES OF GLASSES

Corning Glass	Composition															Softening Point °C.	Temperature Coefficient of Expansion ×10⁻⁶
	SiO_2	As_2O_3	PbO	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	B_2O_3	TiO_2	ZrO_2	Sb_2O_3	MnO	Mn_3O_4		
Pyrex	80.5			2.2				3.8	0.4	12.9						815	3.2
G-702-P	73.76	.46	5.75	1.03	.11	.07	.12			18.70						760	3.6
G-705-H	66.40		2.10	1.85	.21	.22	.79	3.49	.61	24.02	.07	.10				776	3.6
G-720-BE	80.03	.03	.10	2.28	.04	Nil	.09	2.62	1.44	12.90	.10	.10	.09	.02		810	3.1
G-707-DG	70.55	.38	Trace	1.07	.03	.07	.20	2.07	.41	25.22							2.8
G-702-EJ	80.00		.1	1.00				4.4		14.00						800	3.1
G-80	72.40		1.75	5.10		.25	.08	9.75	.40	10.20	.06					735	6.4-6.2
G-81																655	8.5
G-70	69.07	.07	2.05	.70	.10	Nil	.50	3.87	.23	23.35	.04	.10	.11	.01		753	3.6
G-71	67.00		.05	1.17	.27	.25	.28	6.42	.47	19.00	.06		4.80	Trace			4.8
G-1	63.10		20.22	.28		.94		7.60	5.54						.88	620	9.2
G-5	61.62		22.65	.35	.15	.15		12.79	.90						.15	620	8.9
G-6	69.66		Trace	1.22		5.06		18.29	.27						4.63	675	9.8
G-705-AJ	67.3	.14	0.00	1.73	.11	0.00	.20	4.56	.94	24.6			.08	.01		758	4.5
G-8																696	9.5
G-12																627	8.8
G-9709																804	3.8

desired assembly and the entire section is annealed. It was pointed out in the introductory remarks of this chapter that the glass is stressed in such a seal, but the stress is not large enough to break the glass because a very small metal strip is used.

It may be to some advantage to use a Pyrex-to-platinum seal in which mercury is used over the seal to assure a vacuum-tight seal. The seal is shown in Fig. 77A on the side of a bulb (which is part of a manostat). A platinum wire 0.01″ in diameter is used. A Pyrex tube, 5 mm. in diameter

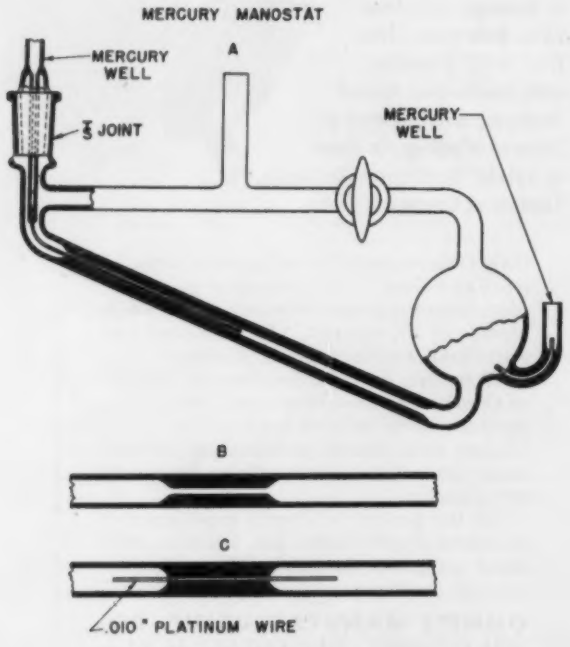

Fig. 77

and 4″ in length is constricted to about the diameter of the platinum wire by fusing the glass as it is rotated in the flame, Fig. 77B. The constricted section should be about a half-inch in length. The wire is slipped into place and should be long enough to extend about a quarter of an inch beyond each end of the constriction. The Pyrex is then fused to the wire by the procedure outlined for coating wire with glass. One end of the tube is then sealed to the manostat bulb. The tube is then bent upward to the position shown in Fig. 77. The bulb and glass-to-metal seal are then carefully annealed.

The tube above the platinum seal is partly filled with mercury which serves as a conductor between the platinum and a lead wire that is put into the mercury. This eliminates the danger of breaking the wire at the glass-to-metal seal because the two are not directly connected. Any small leaks that might develop because of contraction of the wire are sealed by the mercury in the tube.

Tungsten

Tungsten has a linear temperature coefficient of expansion of 4.8×10^{-6} per degree C.; and the glasses in Table 11 recommended for glass-to-tungsten seals are Corning glasses with code numbers of 778, 3320, 772 and 775. Tungsten wire is often fibrous, having longitudinal channels which may leak if sealed in vacuum tubes. Tungsten has a resistivity of 5.48 microhms $(cm.^2)/(cm.)$ at 20°C.; and to decrease the resistance of electrodes of this metal, braided copper is butt welded to one end of the tungsten wire while a thin nickel rod is welded to the other. The butt welds, if carefully made, close the channels at both ends, thus eliminating leaks. These leads are called press welds.

When tungsten is sealed into any of the above-mentioned glasses, a glass-to-metal seal is obtained which is equal to, if not superior to, that obtained between lead glass 001 and platinum. These glasses require a higher temperature for making the seal and consequently there is danger of over-oxidizing the tungsten wire. For this reason a different technique is required when bead or press seals are made. The following procedure is recommended regardless of the choice of the recommended glasses:

1. The wire is first degassed by heating it to white heat in an oxygen-gas flame. This is done to prevent bubbles from appearing between the wire and glass as the seal is made.
2. The wire is then heated and cleaned by rubbing it against a lump of potassium or sodium nitrite.
3. The wire is then thoroughly washed and examined. Any dark portions of oxide on the wire must be removed by repeating the second step.
4. A four-inch length of tubing of the sealing glass, 8 to 15 mm. in diameter, is then drawn down to a thin-wall tube with a diameter approximately equal to that of the tungsten wire. A section of the glass tubing which fits snugly over the wire is then cut to a length of 16 mm., Fig. 78A.
5. The clean tungsten wire is then oxidized by heating it to a *dull red heat*. This oxidizing treatment is the most important step in the entire sealing operation, and can be mastered only by individual practice. If the wire is left in the flame too long it is over-oxidized and a black seal is obtained which is not vacuum tight. If the wire is not oxidized sufficiently, the glass will not have the opportunity to dissolve in the oxide layer and a poor seal will result.
6. The small sleeve prepared in step 4 is then slipped over the wire and it is fused to the tungsten wire at one end, Fig. 78B. The glass is then collapsed and fused to the wire by rotating the wire and heating from the seal end toward the open end. One must be careful not to trap any

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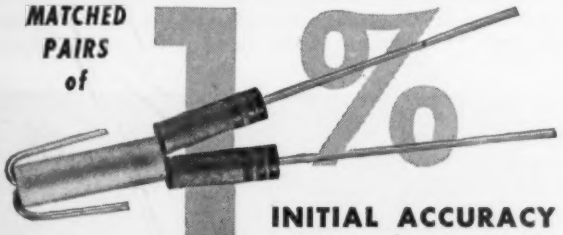

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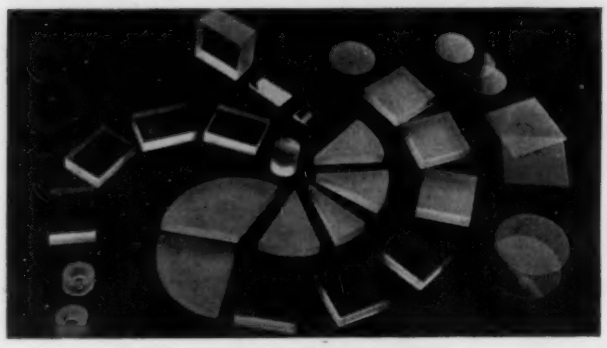

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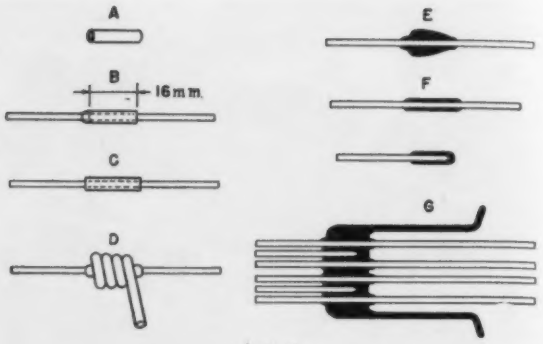

Fig. 78

air between the glass and wire during this operation. By employing the expedient of using a thin glass sleeve, one avoids over-oxidizing the tungsten wire because considerably more heat is required if a thick-walled sleeve is used. The bead formed with this sleeve is thin, Fig. 78C. When a good seal is obtained, the color at the interface of glass and wire ranges from *golden yellow to reddish-brown.* If the interface is black, the wire had been oxidized too much before sealing with glass. Prolonged and successive heat treatments are then required to dissolve the oxide in the glass. It is not advisable to use a blackened seal.

7. If the wire with the thin glass bead is to be used as a single-contact wire through the end or side of a glass tube, more glass must be accumulated on the thin bead to give a sufficient amount of glass for the final seal. This is done by using the same type of glass in the form of a thin rod. One end of the rod is attached to the end of the bead. The rod is then wound and fused to the thin-walled bead as illustrated in Fig. 78D. The rod is cut in the burner flame when enough glass is accumulated and the glass is fused to a pear shaped bead, Fig. 78E. The bead with the wire is then kept hot by placing it on the screen of the Argand burner. The opening which is made in the tube of the same type glass is slightly smaller than the maximum diameter of the bead. The bead is held over the opening as the glass of the tube and bead

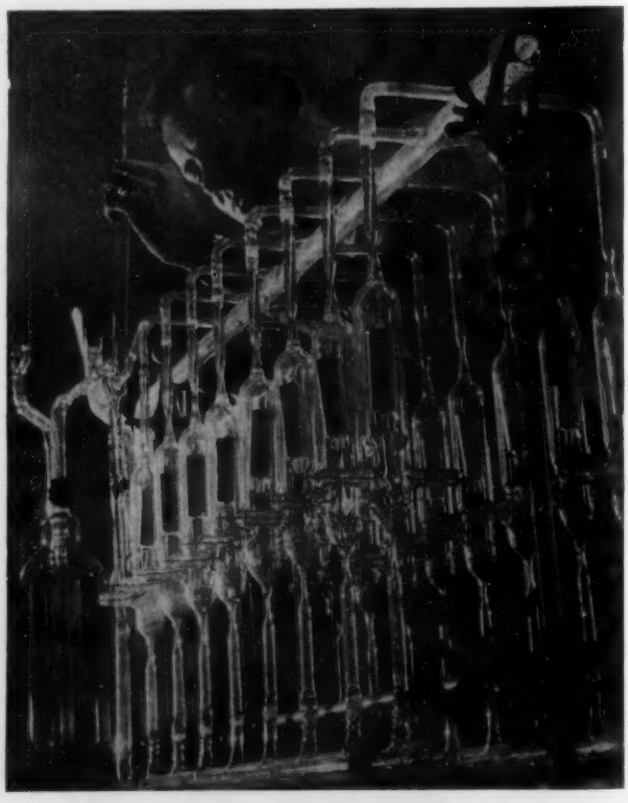

Fig. 79

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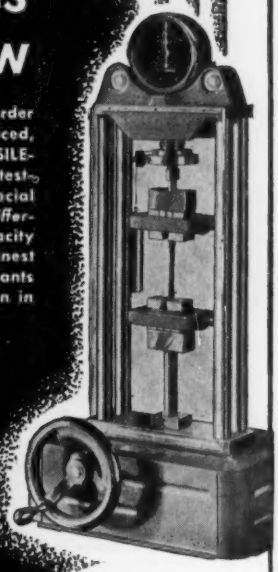

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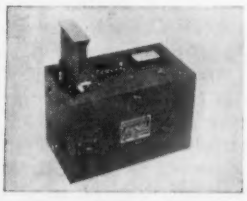

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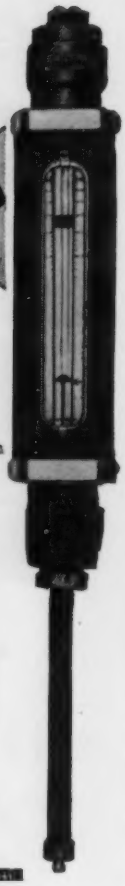

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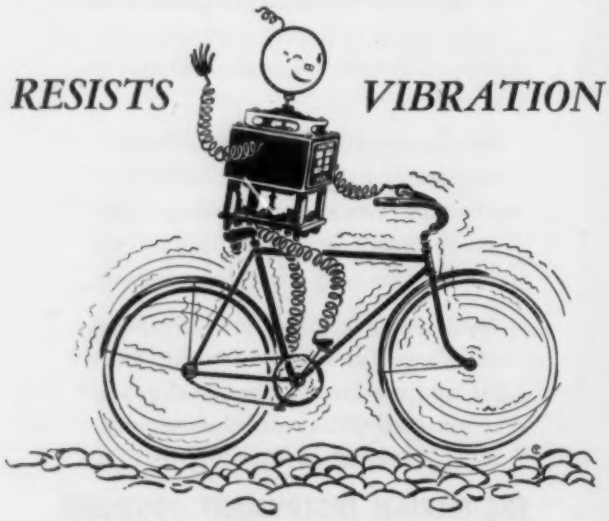

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Fig. 80

are fused sufficiently to allow it to flow together. The seal is then annealed.

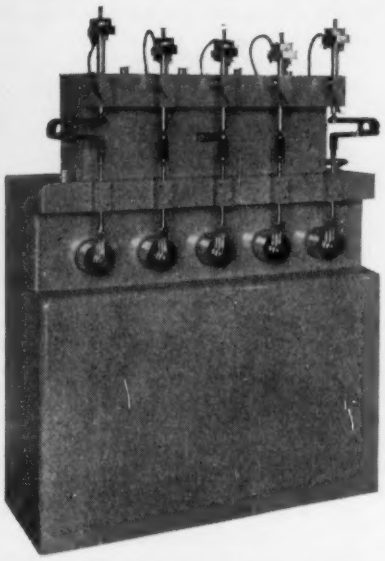
In pinch press construction, the tungsten wire requires only a thin glass layer and any dead wires must have the one end covered and closed with the seal glass as illustrated in Fig. 78F. The glass tube for the press is prepared as previously described. The opening in the tube slot should be wide enough so that all wires can be uniformly spaced. The wires are then mounted in a wire holder, Fig. 95, and the beads are located and held in the tube slot so that a short section of the bead glass will extend beyond both ends of the press. The flat portion of the tube is then heated and, when the glass is sufficiently fused and collapsed against the beads, it is pressed together with a forceps to insure a good seal between the bead glass and the flat end of the tube. The finished seal is shown in Fig. 78G. The entire assembly is carefully annealed.

Tungsten, beaded with Corning glass 778, sealed into Nonex 772, has been very successful as glass-to-metal seals. If a tungsten bead is required in a Pyrex system, a graded seal is required. Such a seal is used in the apparatus shown in Fig. 79. In this case tungsten wire was beaded with glass 778 and sealed into a tube of glass 772, a narrow band of uranium glass 3320 was then sealed to the Nonex 772 tube, and the assembly was then sealed into Pyrex. The recommended sealing order is: Tungsten, glasses 778, 772, 3320 and Pyrex. Glass-to-tungsten seals with glass 3320 have been successful. Glass 3320 can be sealed directly to Pyrex.

Pyrex-to-tungsten seals are impracticable except when the tungsten wire has a diameter of 0.015″ or less. Even then it is preferable to bead the wire with Corning glass 7051 before it is sealed into Pyrex.

An example of a tungsten-to-glass seal is shown in Fig. 80. The large tube contains two 0.09″ tungsten rods which were beaded with Corning glass 778. These beaded rods were pressed into a tube with a 4″ flare of Corning glass 772. The glass blower is sealing the flare into a large bulb of 772 glass. Two sets of rollers are being used to distribute the weight of the large bulb.

A common type of Pyrex thermoregulator, particularly useful in controlling constant-temperature baths, is illustrated in Fig. 81. The essential parts of this regulator are the two contact points. The contact point in the glass-to-metal seal is a tungsten wire. A length of braided copper is butt-welded to the tungsten wire so that a flexible connection can be made. The tungsten is covered with a sleeve of



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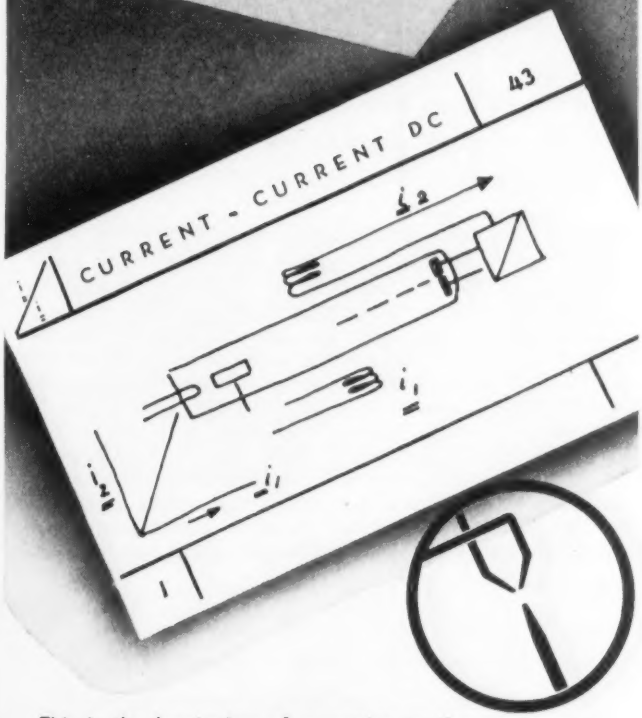

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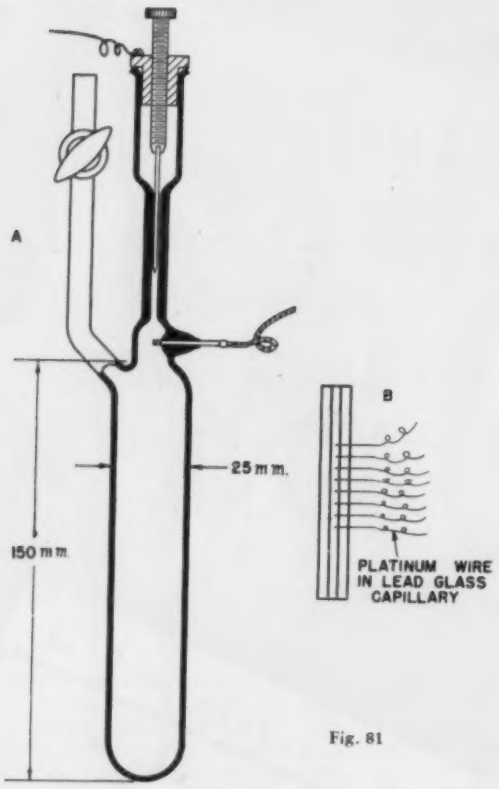

Fig. 81

Corning glass 7051 by the procedure outlined for beading tungsten and the bead is made of Pyrex. The bead is sealed into Pyrex. The stopcock on the side arm is convenient for filling the regulator. It is not necessary, however, for the regulator can be filled through the capillary. By varying the size and shape, other forms of thermoregulators can be made with increased sensitivity. If a mercury reservoir is used, toluene, or a mixture of ethanol and water of 50 parts of each or any other suitable liquid can be used.

A series of contacts is sometimes required in a thermoregulator. These contacts may be made in the form illustrated in Fig. 81B. This glass-to-metal series can be made by using a soft glass capillary tube and platinum wires. The capillary tube is cut and a short piece of unbeaded wire is laid across the glass wall. The capillary tubes are then sealed together. Successive seals are made in this way until all contacts are sealed into the tube. Extreme precautions must be taken when the glass is heated. The assembly must also be carefully annealed. The tube with multiple contacts can be used on any desired thermoregulator.

Molybdenum

Molybdenum has not been extensively used for glass-to-metal seals because this metal has a tendency to oxidize very rapidly as seals are made. The oxide layer becomes thick quickly under oxidizing conditions. This oxide forms a non-adhering semi-liquid layer with the glass and poor seals are obtained. When molybdenum is required for glass-to-metal seals, Corning glass 706 should be used. A long close-fitting sleeve of this glass should be made for beading purposes and oxygen should be excluded as much as possible during the sealing operation. Molybdenum rods up to 10 mm. in diameter have been sealed to glass. Such a seal is shown in Fig. 82A. The sleeve in this seal is 3 inches long.

To be continued

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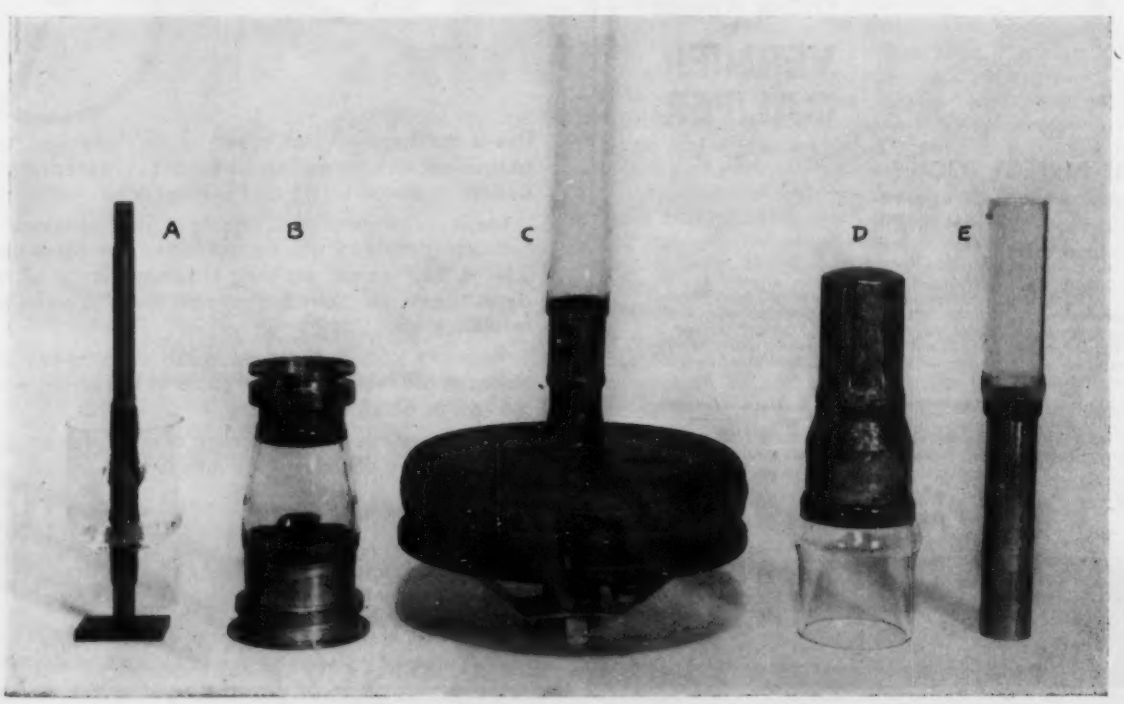
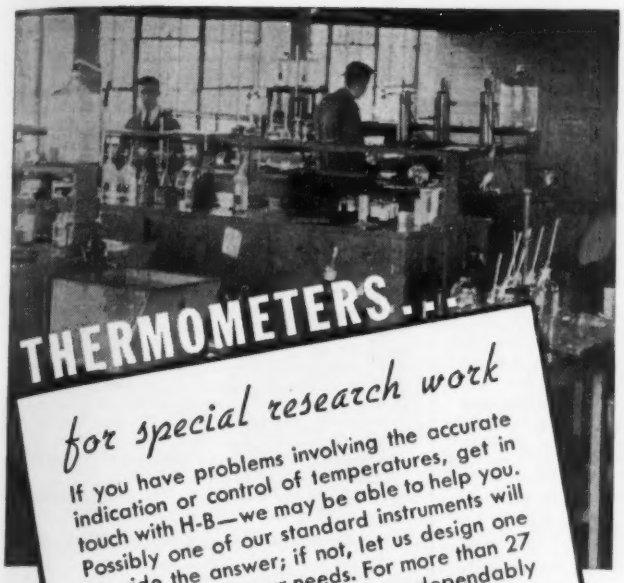


Fig. 82



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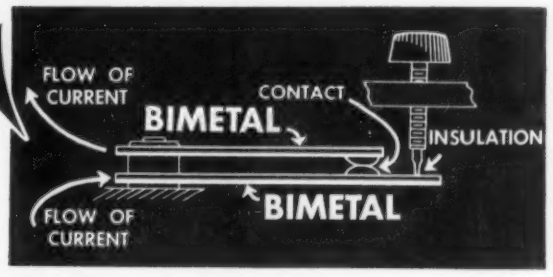

As temperature rises both bimetals bend in the same direction since the high thermal responsive side of each is on the same (lower) side. Contact is maintained until curvature of the bottom element is checked by the stem of the manual selector, at which point the upper element continues to move and automatically break the circuit. Cooling of bimetal reverses the movement.

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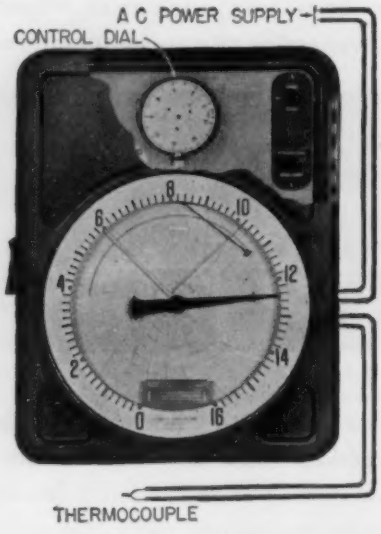
Indicating-recording-controlling Pyrometer Potentiometer

New "Pyrotron Electronic Potentiometer-Pyrometer" has no continuously moving or vibrating parts in its measuring circuit; records one or two temperatures on a 12" diameter uniformly-graduated chart, indicates on a 29" bold scale which encircles chart; has automatic-control features. It requires a 115-volt, 60- or 50-cycle a-c. power supply. It operates from a thermocouple or from any source of d-c. potential which varies through at least 10 millivolts for full-scale range. Conventional thermocouples are used for temperatures up to 3000°F. For temperatures above 3000°F. and for moving objects above 1500°F. radiation type thermocouples are used. D-c. potential of thermocouple (or other primary element) is



balanced against a conventional potentiometer circuit employing usual battery source of d-c. voltage and a standard cell with manual standardization. Instead of a galvanometer or millivoltmeter "Pyrotron" potentiometer circuit employs a d-c. to a-c. converter and an electronic detector to measure potentiometer unbalance. Trouble-free service and minimal maintenance are said to be insured by elimination of all continuously moving or vibrating mechanisms from measuring system. Only recording chart moves continuously; reversible electric motor which drives indicating, recording and controlling features moves only when potentiometer network tends to become unbalanced because of a change in the condition being measured. Conversion of d-c. potential to a-c. is accomplished by special saturable-core reactors containing no moving or vibrating parts. Instrument is said to be an effective controller for temperature since its inertia-free electronic detection and high-speed motor system instantly respond to keep measuring circuit in continuous balance. Its accuracy, stability and permanence of calibration are credited to the use of the null balance principle. To halve panel space, each potentiometer may be furnished with two controllers operating from two separate measuring circuits housed in the same recorder casing. "Pyrotron" recorder-controllers are furnished for (1) air-operated control systems, (2) on-off electric and (3) throttling type electronic control systems. Instrument illustrated is cut away to show control dial by which setting point may be manually adjusted to desired temperature. This arrangement is used for the on-off electric and throttling electronic type controllers; air-operated controllers are provided with an indicating pointer which uses the recording chart as a scale for indication of the setting point; setting point may be changed by simply opening door and turning a knob. "Pyrotron" instruments are made up of a number of interchangeable sub-assemblies standardized so that only a few spare parts need be carried in stock for a large number of instruments. Electronic amplifier unit and a-c. to d-c. converter are both mounted in die-cast housings which plug into rear of recorder casing.—*Bailey Meter Co., 1041 Ivanhoe Road, Cleveland 90, Ohio.*

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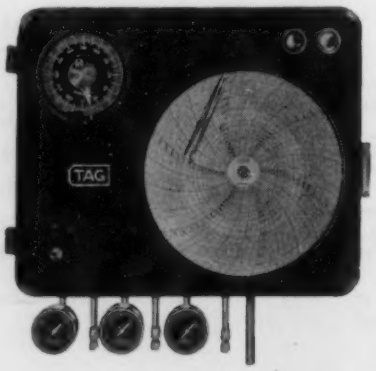

sing completely from start to finish. By use of an adjustable cam, timing starts automatically when temperature reaches processing point and is terminated at desired moment. All valves, whether steam, air, water or overflow, are opened and closed as process may require without manual attention. A red light glows during steam-heating phase of process; when heating has been completed and steam has been shut off red light goes out and a white light appears. At end of cooling time, white light goes out, signaling to operator that cycle has been completed. New controller is adaptable to many processes involving control of temperature and pressure in the manufacture of rubber, plastics, chemicals and textiles.—*C. J. Tagliabue Div., of Portable Products Corp., 549 Park Ave., Brooklyn 5, N. Y.*

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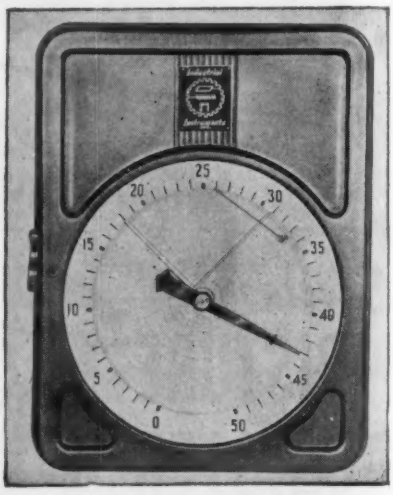
Conductivity Recorder

New "Type RP Solubridge Recorder" is for recording electrolytic conductivity of solutions, condensates or water by "Solu-



bridge" method. It operates on null balance principle, so that accuracy is independent of line-voltage fluctuations and vacuum-tube characteristics. It can be furnished for 1, 2, 3 or 4 continuous-line records on the same 12" chart, a separate amplifier and motor-driven slide wire being used for each pen so that no switching devices are necessary. All pens of a multiple-pen recorder may move at any time or simultaneously. Slidewire unit mounts on inside of hinged panel in back of door; amplifier is normally mounted on rear of recorder casing, is a standard and interchangeable unit. Optional equipment (though shown in illustration) is a 29" indicating scale and bold indicator pointer, illuminated by (also optional) built-in fluorescent lamp. Indicator can operate in conjunction with only one pen, its use limits recorder to a maximum of three pens instead of four. Recorder may be provided with a control switch operated by an adjustable cam set to trip at any desired position of pen or pointer. Up to four switches, individually adjusted, may be provided on the single-pen recorder; or two independent slidewire units in the same recorder housing may be equipped with control switches. In addition to Micro-switch on-off contacts, air-operated proportioning control feature can be supplied.—*Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.*

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Apparatus for Non-destructive Acoustic Detection and Location of Interior Flaws

New "Type B Supersonic Reflectoscope" is industrial model of laboratory apparatus (now called "Type A") developed at Univ. of Michigan (F. A. Firestone: U. S. Pat. 2,280,226, appl. May 1940, issued Apr. 1942) for measurement or non-destructive testing of solid parts for flaws by sending supersonic sound waves into the part and observing reflections from boundaries of part or

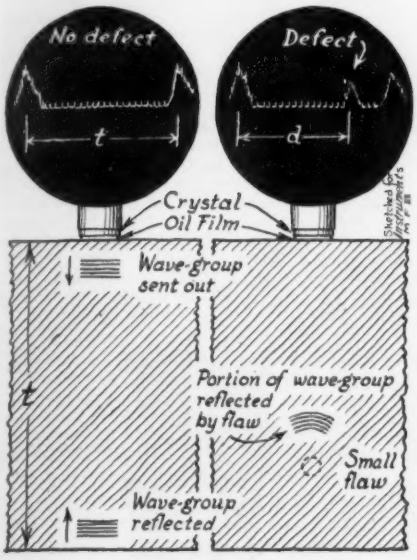

Fig. 1

from any flaws within it. Principle, roughly sketched in Fig. 1, is similar to that of radar except that pulses are not radio waves but material vibrations radiated at 5-Mc. frequency during one microsecond at a 60-cycle repetition rate, so that a five-wave group is sent out sixty times per second. Quartz crystal is utilized not only to convert electrical oscillations into vibrations but to convert echoes into electrical signals. Pulses and echoes both show on a cathode-ray oscilloscope screen, together with microsecond timing "notches" which are used for linear measurements because velocity of sound in material being tested is known. Only a rough idea of possible techniques is given by Fig. 1. For example, vibration frequency being determined by crystal, heads fitted with crystals of various frequencies can be interchanged. Likewise, curved crystals may be substituted for standard flat ones when mass inspection of cylindrical parts is called for. Furthermore,

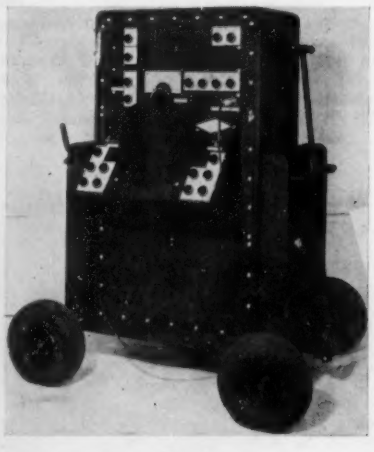

Fig. 2

one crystal can be employed as transmitter and a separate crystal as pick-up. Accuracy of linear measurements is approx. 1/16"; accuracy of direction is roughly shown in Fig. 1: it is due to the fact that megacycle-frequency vibrations travel in a narrow beam, so that with a 0.25 in.^{2} crystal, lateral location of a small flaw can be determined to approx. 1/8". In exterior view of "Type B," Fig. 2, indistinct black portion in center is a hood for convenient viewing of 'scope screen, which is 9" in diameter.—*Sperry Products Corp., 16th & Willow Sts., Hoboken, N. J.*

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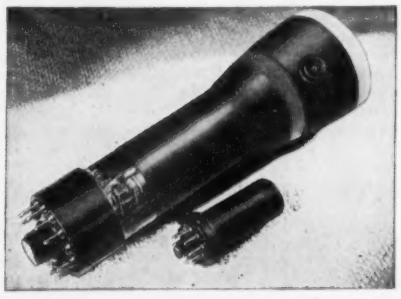
High-brilliance High-deflection-sensitivity C-r. Tube

New "Type 3JP" cathode-ray tube, characterized by exceptional brilliance and high deflection sensitivity, is annouced as the logical successor to wartime "3BP" and "3FP" and is said to combine the best qualities of each, thus being suitable for equipment which must be operated under extremely strong ambient light conditions. Focusing electrode current under operating conditions is negligible, thereby simplifying bleeder design. The 2" neck and diheptal base provide adequate insulation between electrode leads for high-altitude installation. For applications where deflection voltages are under suitable control, "3JP" is interchangeable with "3FP." Equipment



using "3BP" may be adapted to use "3JP" by providing for connecting intensifier electrode of "3JP" either to second anode potential or to a higher potential than second anode. Owing to higher deflection sensitivity of "3JP," it can be utilized with intensifier potential equal to twice second anode potential. New tube is on Joint Army-Navy Preferred List.—*Allen B. Du Mont Labs., 2 Main Ave., Passaic, N. J.*

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Intermodulation Analyzer

New intermodulation test equipment consisting of a signal generator and intermodulation analyzer is designed to facilitate the measurement of intermodulation distortion in all audio amplifiers, AM and FM broadcast transmitters, film, disk and tape recording, reproducing equipment and loudspeakers. Signal generator (one unit which is portable or can be rack mounted) contains two independent sine wave oscillators and combining units: low-frequency oscillator supplies 40, 60, or 100 cycles; high frequency oscillator supplies 1000, 7000 or 12,000 cycles. By means of switches and controls any low frequency may be combined with any high frequency for the test. Intermodulation analyzer (a second unit of similar construction) contains necessary input controls, power absorbing network, filters, demodulator and indicating instruments to measure intermodulation distortion directly in percent. Sensitivity is such that it can read distortion from 0.1% up to 100%. Switches are provided so that in addition to reading intermodulation, internal vacuum-tube voltmeter can read volts and millivolts and has a full-scale sensitivity from 0.3 millivolts up to 100 volts. Analyzer is capable of directly reading intermodulation distortion, noise levels and output power on equipment being tested over a range from 50 watts (+47 dbm) down to —90 dbm.—*Altec Lansing Corp., 1161 North Vine St., Hollywood, Calif., and 250 West 57th St., New York 19, N. Y.*

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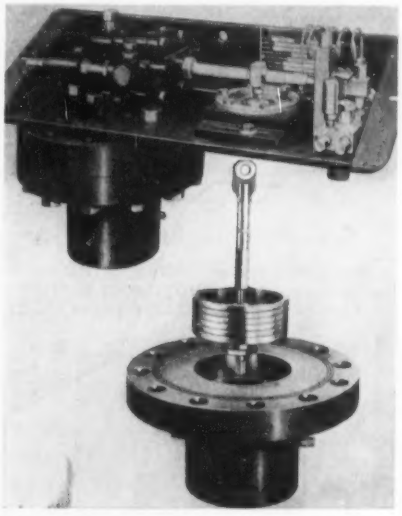
Flow-rate Transmitter for Metering Hot Liquids

New pneumatic transmitter (shown with cover removed) is designed for measuring flow of hot liquids, which are so viscous at



room temperature that they congeal in the lead lines. A piston is used instead of the ordinary diaphragm in order to avoid the effect of hot liquids on diaphragms. (Nonmetallic diaphragms are not usable above about 200°F., and metallic diaphragms might give erratic results at high temperature.) New transmitter is designed for installation in a manner that keeps measuring chambers hot enough to prevent measured fluid from congealing in transmitter chambers and lead lines. Piston and cylinder are made of steel of the same composition, to assure constant clearance regardless of temperature changes. Among successful uses: measurement of coal tar pitch at a flowing temperature of 550°F., and flow of petroleum tar at 600°F.—*Republic Flow Meters Co., 2240 Diversey Pkwy., Chicago 47, Illinois.*

Please mention number 607 when filling out card

Three-phase Type Generator for Electric Tachometers

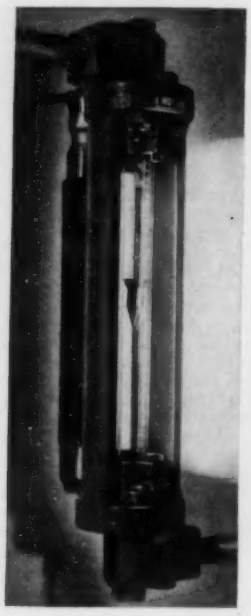
New "Compak Generator" weighs less than 23 oz., is said to be "more than sixty percent smaller than many types now in use." Among claimed advantages are easi-

er maintenance and inspection, lower cost and improved operational characteristics. Although designed primarily for use with tachometer indicators in aircraft, new generator has a variety of potential industrial applications. It is interchangeable with other generators of standard a-c. three-phase type used with electric tachometer indicators of magnetic-drag type. It is applicable to tachometer engine outlets operating in either direction. It is designed for use where tachometer indication for each engine is required at only one station and, like standard generators, operates from tachometer engine outlets operating at one-half engine speed. Where installed in aircraft, output of unit is sufficient to actuate both a tachometer instrument and a synchroscope instrument and may be used with special Kollsman helicopter tachometers. Where duplicate engine instruments are required, "Compak Generator" may be operated at crankshaft speed, using a two-pole arrangement.—*Kollsman Instrument Div. of Square D Co., Elmhurst, L. I., N. Y.*

Please mention number 608 when filling out card

Rotameter Lighting Device

New inexpensive lighting device for recently-announced "SK Universal Rotameter" (see *Instruments, April* 1944, pages 242-244)

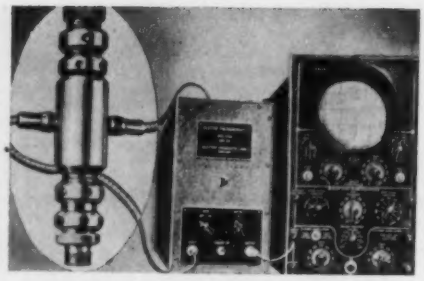


is an easily-attached baked-enamel metal hood with narrow frontal opening, which fits snugly against back of Rotameter tube and directs a beam of light through the glass toward the operator. Rotor and scale are clearly outlined even when metered fluid is semi-opaque. Push-button socket, 10-foot rubber-covered attachment cord and plug are included. Device uses a 110-volt tubular incandescent lamp obtainable from any electrical supplier. — *Schutte & Koerting Co., 12th and Thompson Sts., Philadelphia 22, Penna.*

Please mention number 609 when filling out card

Pressure Pick-up and Amplifier

New "Pressuregraph" is said to embody important improvements over original model (described in *Instruments*, April 1945, page 274). It provides, with a cathode-ray oscillograph, a substantially linear pressure-time curve on the screen, which indicates the performance of any engine, pump, compressor, air and liquid pipe line or other device subject to pressure variations. In addition to dynamic pressure variations, it shows static or slow pressure variations. It

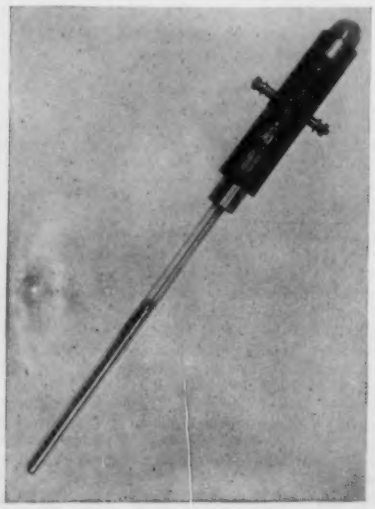


covers all mechanical speeds, and pressures up to 10,000 lbs./in.^{2}. There is no appreciable inertia to overcome in the electronic driving mechanism. New model provides means for temperature compensation. There are three output selections: (1) for double modulated wave; (2) for indicator card wave; (3) integrated single line providing means for transmission of pick-up response to a string oscillograph, for photographic recording. Completely redesigned pick-up is vibration proof, is furnished with or without water-cooling. New cabinet construction provides special convenience with better arrangement of connections. Operation is simple. There is only one control. Pick-up diaphragm, when acted on by pressure, unbalances an electronic circuit. Unbalanced voltage from pickup is delivered to "Pressuregraph" cabinet where it is amplified and passed through a negative modulation suppressor, and then to oscillograph. Sweep circuit of oscillograph is adjusted to speed of mechanism under test. Pressure-time curve on screen is not a line or tracing, but a solid area easily readable.—*Electro Products Laboratories, 549 West Randolph St., Chicago 6, Illinois.*

Please mention number 610 when filling out card

Thermoregulator with Signal Light

New "Mercuroplat" Thermoregulator has a signal light, either red or white, which glows while temperature is rising and shuts off when setting temperature is reached, thus permitting operator to perform other duties. New regulator is intended for accurate control of temperatures in water, oil, or air baths; ovens; etc., at any temperature within the setting range from 30°F. to 500°F. It has a sensitivity of ± 0.02°F. or better. It is available in 6", 8", 10", or 12" lengths, has durable machined plastic head whose design provides full visibility for easy setting, a convenient means for mounting, and an appropriate mounting for signal light (which can readily be replaced). Said to contribute to regulator's accuracy and long life is manufacturer's improved distilling and filling method by which mercury is distilled directly into regulator

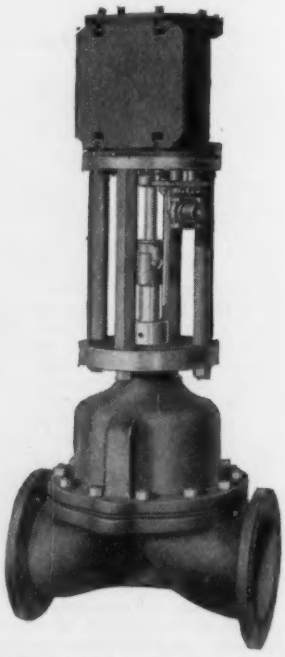


without being exposed at any time to atmospheric air, thus assuring purity.—*Washington Glass Laboratory and Instrument Co., 3224 Georgia Ave., N. W., Washington 11, D. C.*

Please mention number 611 when filling out card

Air Operation for Diaphragm Valves

New pneumatic power devices are available for maker's "Saunders Patent" diaphragm valves in 4" to 12" sizes. Application of air control to this valve was made to meet requirements of remote control operation of valves on paper and pulp mill stock lines. It is equally applicable to service in chemical and process plants for flow control of acids, caustics, slurries and other fluids. "Westinghouse Flexair" control is applied to valve for simple open and close operation. "Flexair" and "Controlair" are applied to provide opposed air operation for smooth throttling over a wide range. Unit is readily adapted for instrumentation and use with positioning devices. An auxiliary air tank is included to provide shut-off in event of failure of main air supply. Diaphragm valve itself (as a manually-operated unit) has been used for over 14 years. In this valve,



working parts in bonnet are completely isolated from the flow, preventing contamination of material and corrosion of working parts. Absence of stem packing makes this valve especially adaptable to air control. Valve is leakproof because diaphragm will seat tightly even in presence of small foreign particles. It is claimed that it is almost impossible for valve to become clogged.—*Hills-McCanna Co., 3025 N. Western Ave., Chicago 18, Illinois.*

Please mention number 612 when filling out card

Automatic Timers for Photographic Work

(1) New "Model TM-5 Electronic Photo Timer" features complete finger-tip control with two positive-setting, visible interval dials and three double-contact toggle switches. It provides 105 time intervals: 55 from 0.2 second to 11 seconds in steps of 0.2 second; and 50 from 11 to 60 seconds in one-second steps. "Model TM-5" represents improvements over "TM-4" developed for U. S. Army Signal Corps. Accuracy is guaranteed within 0.05 second or 10% of

pre-set time interval. For enlarging work, timer may be kept "on" indefinitely for easy focusing; exposure started by a flip of finger and turned off at will. "Model TM-5" measures 5½" × 8" × 3¼", weighs 3 lbs., operates on a.c. or d.c.

(2) New "Model TM-5-R" has same range of 105 time intervals as "TM-5." When in use with a contact printer, contact is made from a special outlet in timer to platen switch of printer so that when platen is closed it automatically starts timing cycle. For enlargement work, a foot-switch can be inserted in outlet. In both enlargement and contact printer work, timer automatically stops exposure at the end of the pre-selected interval. "Model TM-5-R" measures 5½" × 8" × 3¼", weighs 3 lbs., operates on a.c. or d.c.—*Lektra Laboratories, Inc., 30 E. 10th St., New York City.*

Please mention number 613 when filling out card

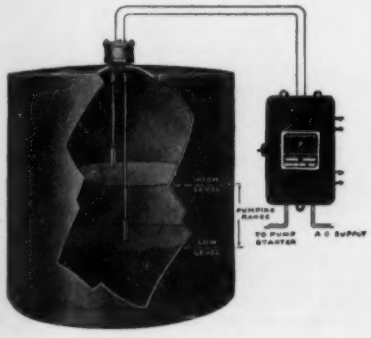
Infra-red Gas Analyzer

New models are announced of "Infra-Red Gas Analyzer" described in *Instruments*, Sept. 1945, page 644. This is an instrument for the continuous recorded analysis of gases. Several modifications are said to result in greatly increased sensitivity and consequent stability over wide ranges. Recently developed attachments are provided for use with conventional potentiometer-type recorders such that the instruments are automatically standardized at frequent intervals. Modified instruments are suitable for use in many fields where control or observation of gas concentration is desirable. Each instrument may now be sensitized to practically any gas exhibiting infra-red absorption and an analysis made for this gas, even though it exists in the presence of similar gases.—*Baird Associates, 34 University Road, Cambridge 38, Mass.*

Please mention number 614 when filling out card

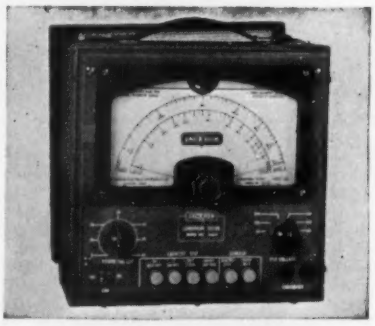
Liquid Level Controller

New "Level Control Series 10" is described as a series of rugged maintenance-free relays for level control of all electrically conductive liquids. Contact with liquid is made by a stainless steel probe rod. With a.c. in probe circuit, no electrolytic action is possible. Mica insulated probes insure against leakage. "Series 10" is said to be



DETECTS SMALL LEAKS

Condensers with even the slightest leakage will not get by this compact, modern tester. You get positive indication on the electron ray tube and the correct reading on the easy-to-read expanded scale.



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MODEL 650-A
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Automatic Push Button Controlled—Amazing in speed and simplicity of use. Capacity readings almost instantaneous! Leakage test by just pressing a button.

The Model 650 is a modern accurate and complete instrument for detecting faulty condensers—Electrolytic, Paper or Mica. New method for Leakage Test reveals otherwise unnoticed condenser defects.

Scale is Glass Enclosed and is equipped with the new Jackson Scale Expander indicating pointer — doubles effective scale length.

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Ranges

.00001 to .001 mfd.	.1 to 100 mfd.
.001 to .1 mfd.	50 to 1000 mfd.

Measures Power Factor on direct reading dial. Power Factor range calibrated from 0 to 60%.

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Electron Ray Tube indicates exact balance or shows if leakage is present.

Instantaneous Leakage Indication—Counting of flashes eliminated. No other guess-work with this modern tester. Has special built-in amplifier stage which actually responds to slightest leakage, if present. Thus all leakage defects may be located.

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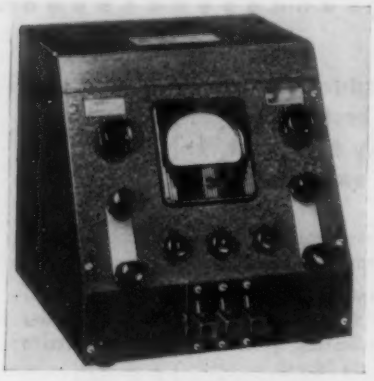
the only floatless level control containing no vacuum tubes and operating with low voltage in probe circuit. Liquid to be controlled makes or breaks contact with probe and transmits to controller a minute electric current at low voltage. Without the use of vacuum tubes, this current controls a power circuit which operates a relay to actuate signals, valves, or pumps. Specifications—Supply: 115 or 230 volts, 50/60 cycles a.c.; total power consumption ½ watt. Output: single-pole double-throw relay. Contacts: designed for motor starter, motorized, or solenoid valve operation; arc suppression is supplied on both contacts for increased contact life. Probe Circuit: will carry a resistance as high as 3500 ohms. —*Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.*

Please mention number 615 when filling out card

Resistor-testing Bridge for Mass Production

New "Model 81-A Low Range Limits Bridge" is particularly adapted to testing resistance values of motor windings, transformer primaries or secondaries, rheostats, lamps, shunts, multiplier resistors, etc. With it, anyone can quickly learn to check large or small resistance values. To operate, connect resistor and press test and limits

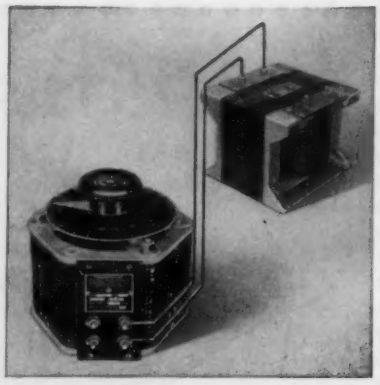


keys: if pointer stays within plus or minus marked limits, accept resistor; if pointer moves outside limits, reject it. Resistance from a fraction of an ohm to 20,000 ohms may be checked to tolerances of ± 1% to ± 20%. Plus and minus tolerances are separately adjustable. "Model 81-A" uses three No. 6 dry cells, or an external battery where higher sensitivity is required. Bridge does not have to be specially leveled or installed on test bench.—*Associated Research, Inc., 231 S. Green St., Chicago 7, Illinois.*

Please mention number 616 when filling out card

Variable Voltage Transformer for Power Line Voltage Regulation

New "Type LC" combination consists of a "Powerstat" variable transformer and an auxiliary fixed-ratio transformer, for use in remote locations (and on heavily-burdened factory power lines) where voltage varies in substantial increments throughout the day, these variations being not rapid fluctuations requiring automatic voltage control but slow deviations from nominal line voltage. To compensate for these off-nominal line voltages, "Powerstat" is connected across the power lines and supplies a variable voltage to primary side of step-down transformer whose secondary winding is in series with one side of the line. This combination is so arranged that when dial pointer (and consequently movable brush contact) is situated approx. in center of "Powerstat" coil winding, no voltage is applied to primary winding of fixed-ratio transformer. Thus, no voltage is generated in secondary winding and output voltage of combination is the same as line voltage. However, if brush contact is rotated in either a clockwise or counter-clockwise direction away from mid-position, a voltage is applied to step-down transformer, bucking or boosting incoming line voltage to the desired value. Since "Powerstat" is operating at line voltage and secondary of the step-down transformer at a much lower voltage, high current loads are easily handled with a "Powerstat" of small physical size and low current rating. New "Type LC" may also be used on a constant-voltage line to furnish a variable output voltage over a limited range at relatively large power output capacities. Single- and three-phase combinations are available to operate from 115-, 230-, or 440-volt source. They are offered in manually- and motor-operated models.—*Superior Electric Co., Bristol, Conn.*



Please mention number 617 when filling out card

A-f. Frequency Meter and Tachometer

New "Model 1800" is designed for measuring frequency of a-c. voltages over entire audible frequency spectrum. In conjunction with new "Model 1900 photo-beam converter," it instantly becomes a tachometer for measuring the speed of rotating or reciprocal mechanisms, including those which cannot be subjected to any additional mechanical load. Speeds in excess of one million r.p.m. or c.p.m. can quickly and easily be measured. Instrument can also be used to measure relatively slow speeds in the order of 60 r.p.m. or c.p.m. with equal accuracy and ease, by means of a special "frequency-multiplying" disk or similar device. When "Model 1800" is correctly calibrated at only one point, such as 60% or full-scale, its accuracy is better than 1% at full scale and is equally good at 1/10 of full scale and at all other intermediate points, actual error in any case depending largely on so-called "decade accuracy" of indicating instrument. "Model 1800" can measure frequency of positive or negative "radar-type" pulses from a fraction of a microsecond to more than 50 microseconds in duration. A separate input jack is provided for pulse operation. Wave input circuit will accept voltages of practically any wave-form having a duration of 50 to 100,000 microseconds (20000 to 10 c.p.s.). Thus, inasmuch as these two ranges overlap, operation can be said to be independent of wave-form. Accuracy of "Model 1800" is substantially (0.1% to 0.2%) unaffected by line-voltage

variations of 105 to 125 volts, by temperature variations from 0°C. to 70°C., or by high relative humidity. "Model 1800", in conjunction with two "Model 1900" photo-beam converters, can be used in study of gear mesh, torque, and dynamic strain, as indicated by relative difference in speed of two rotating shafts. Outputs of the two photo-beam converters can be mixed electrically so that instantaneous speed difference will be continuously indicated, provided that difference is 60 r.p.m. or greater. Vibration rates can be measured with a suitable pick-up device. Sounds detected by microphones or phonograph pick-ups can readily be checked for frequency or pitch. Indicating instrument has a suppressed-zero movement and and a hand-calibrated logarithmic scale. Operation of counter circuit is linear, however, so that an external 0-1 ma. d-c. milliammeter can be plugged in. This permits local and remote readings simultaneously, as well as graphic records. — *Communication Measurements Laboratory, 120 Greenwich St., New York 6, N. Y.*

Please mention number 618 when filling out card

Electrical Multi-tester

New "Volt-Ammeter" is for use in laboratories, general service testing and schools, as well as by amateurs. Its outstanding

feature is that when measuring voltage or current, user connects the individual shunt or multiplier manually and immediately visualizes the specific circuit connection and range. A built-in drawer holds a supply of coded shunts and multipliers, as well as fuses for easy replacement. New "Volt-Ammeter" is said to be the only instrument on which a hermetically-sealed indicator is used. An additional safety factor is an instrument fuse, immediately replaceable from front of panel by means of an insulated fuse extractor post. Indicating instrument, shunts and multipliers are accurate to 1%. Voltage multipliers will give a range from 1 to 1,000 volts and shunts a range from 2.5 ma. to 10 amperes. Flexibility and low price of "Volt-Ammeter" are said to enable many schools to provide every student with his own portable precision test instrument. A special model for school use has an automatic inserting and extracting arrangement to avoid possible body contact during the changing of shunts and multipliers. There are four models, namely: "Model 333" for d.c., "Model 334" for a.c. and d.c., "School Model 343" for d.c. and "School Model 344" for a.c. and d.c.—*Reiner Electronics Company, Inc., 152 West 52nd St., New York 1, New York.*

Please mention number 619 when filling out card

Direct-coupled Amplifier

New "Model 1000 DC" was developed for all amplifier applications requiring a wide pass-band and low inherent amplitude and cross-modulation distortion, is particularly adapted for microphone and speaker measurements, etc. It utilizes a new signal self-balancing and current drift-correcting direct-coupled output circuit. Response is 20

to 20,000 cycles ±1 db. Develops 23 watts with less than 1% total distortion. Less than 0.5% is present at 12-watt level. Overall gain; 96 db. Hum and noise level; —40 VU. Two independent inputs (each of 500,000 ohms) are provided. Balanced output terminals are provided for 4/8/16 and 500 ohms. In-between terminals provide following additional output impedances: 1/2/6/10/12/83/100/125/150/166/175 ohms. Non-frequency discriminating scratch suppressor effectively reduces scratch by 10 db. Non-overloading push-pull expander provides a continuously-adjustable control up to 10 db expansion, introducing less than 1.5% distortion under full expansion. Fixed bias is employed in output stage with a novel delayed plate voltage circuit. Plate voltage is automatically applied within 20 seconds after unit is first turned on. Time delay interval is a function of the "off" period. Filtered d.c. having less than 0.03% ripple is applied to heaters of input tubes through a regulating ballast resistor. Entire input section is mounted on a floating plate. Other features include Expander Attack Time Control and Dialogue Filter. Unit is guaranteed for five years. Power consumption 150 watts. Overall dimensions 17¼" × 10" × 10". Net weight 40 lbs. Furnished complete with input cables.—*Amplifier Co. of America, 398 Broadway, New York 13, N. Y.*

Please mention number 620 when filling out card

Vacuum-tube Voltmeter

New "Type AA-1" high-sensitivity vacuum-tube voltmeter has been designed especially for laboratory and industrial electronic testing. It has ten calibrated voltage ranges: 0.01, 0.03, 0.1, 0.3, 1, 3, 10, 30, 100, 300 volts, so that a wide range of measurements can be made without reading below one-third of full-scale value. For all frequencies between 15 cycles and 500 kc., accuracy is ±3%; and between 500 kc. and 1 Mc. it is ±5%. Instrument can be used with reasonable accuracy between 10 to 15 cycles, and 1 to 1.5 Mc.; is also graduated in decibels and covers a range of —65 to +45 from a reference level of 6 milliwatts into 500 ohms. Input resistance is 2 megohms. A ten-position push-button switch mounted on front panel allows any working range to be selected without passing through intermediate ranges. New vacuum-tube voltmeter is contained in an aluminum case with sloping front panel and leather handle at top. Weight of unit

Everything you need . . .

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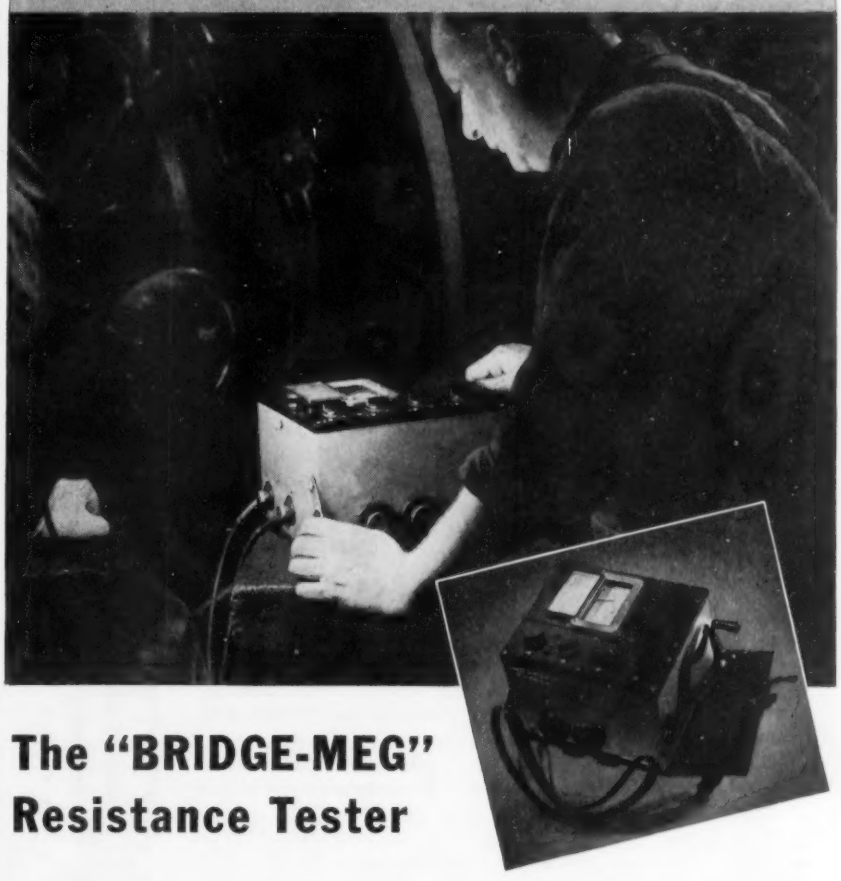
From .01 ohm to 200 megohms - IN ONE "MEGGER"* UNIT



The "BRIDGE-MEG" Resistance Tester

HERE is a combined "Megger" Insulation Tester and Wheatstone Bridge that has been proved by years of service, and that can be used to measure almost any resistance encountered in electrical equipment—anywhere and at any time. It measures conductor resistance from as low as .01 ohm up to 999,900 ohms, and can be supplied withVarley loop test facilities. It measures insulation resistance from 10,000 ohms up to 200 megohms. Having a self-contained constant pressure generator rated at 250, 500 or 1000 volts d-c, it is independent of batteries or outside source of power supply, and is portable, compact and simple to operate.

To all who have electrical equipment to install or to maintain, and who appreciate the advantages of one superior instrument for all resistance measurements, we recommend and offer the "Bridge-Meg" Resistance Tester. Weight 14 lbs. Dimensions 7" x 8¾" x 12".

For complete description write for Bulletin 1615-I.

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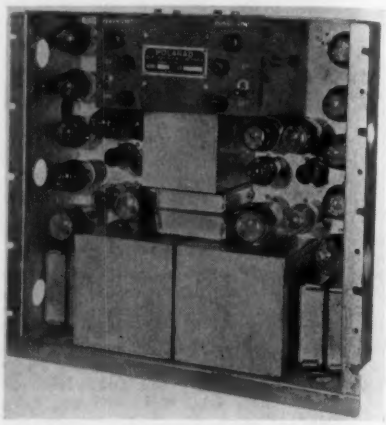
is 13 lbs. Dimensions are 11" long, 10¾" deep, 9½" high.—*Meter and Instrument Division, General Electric Co., Schenectady, N. Y.*

Please mention number 621 when filling out card

Regulated Power Supply

New dual regulated power supply is for television equipment and other apparatus which frequently require d-c. power units



having extremely fine regulation and low ripple content. Unit consists of two independently regulated d-c. power supplies, each capable of delivering 400 milliamperes at 300 volts. Ripple content is less than 0.001% and output impedance is less than 1.5 ohms. Voltage adjustment is provided to permit its use in the range from 240 volts to 300 volts. Unit operates from 115 volt, 50/60 cps. power mains. This new regulated power supply fits in a standard relay rack and occupies 17"×19" of panel space. Mechanical features include dishpan construction, to facilitate servicing from front or rear without removal of the unit from the rack. Each power supply has a separate "On-Off" switch, fuses, and pilot light. No electrolytic capacitors are used.—*Polarad Electronics Co., 135 Liberty St., New York 6, N. Y.*

Please mention number 622 when filling out card

Electric Hygrometer

New "Aminco-Dunmore Electric Hygrometer" was developed for high-precision humidity measurement and control. It uses sensing element claimed to be speediest device known for measuring humidity changes,

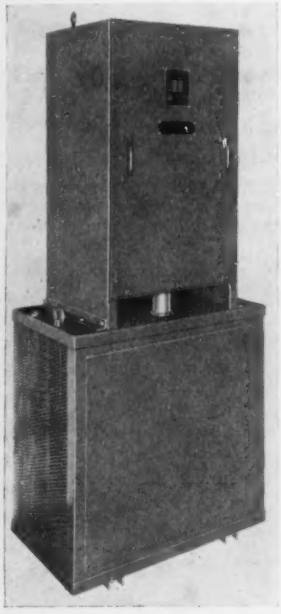
compact, precise, and instantly responsive to microchanges in relative humidity. "Electric Hygrometer" gives reproducible readings throughout standard dry-bulb temperature range of 40°F. to 120°F., and relative humidity range of 7% to 100%. Microchanges within ±0.5% relative humidity are instantly sensed, indicated, or recorded within standard temperature range. Observational errors that occur when measuring or controlling relatively low temperatures and humidities are not greater than when measuring moderate or high temperatures

and humidities. "Electric Hygrometer" does not add moisture to or remove it from the space whose moisture content is being measured or controlled, consequently true readings of relative humidity are obtained, even in sealed spaces.—*American Instrument Co., Silver Spring, Md.*

Please mention number 623 when filling out card

Power Factor Regulator

New "Haug System Power Factor Regulator," when connected to the lines of commercial power users, will raise the power

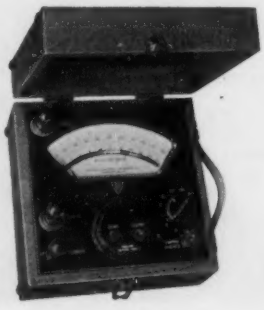


factor by taking the magnetizing current off the line. It is said that this is accomplished with a negligible operation cost and that, by increasing the power factor, reglator will greatly reduce the monthly power bill. New regulator will also increase low voltage to desired value where voltage was previously low by reason of poor power factor. Connected apparatus will function smoothly, resulting in more uniform and efficient operation of all motors and machines — particularly welding machines— and a substantial saving in man-hours through greater line stability and apparatus efficiency. Reactors and transformers are of dry type construction. New regulator has no moving parts; is small in size; can be installed in almost any desired location; requires no discharge coils or other safety devices; is made under A.I.E.E. specifications and N.E.M.A. standards. No fire-proof enclosures are necessary. *Modern Controls, Inc., 176 W. Adams Street, Chicago 3, Illinois.*

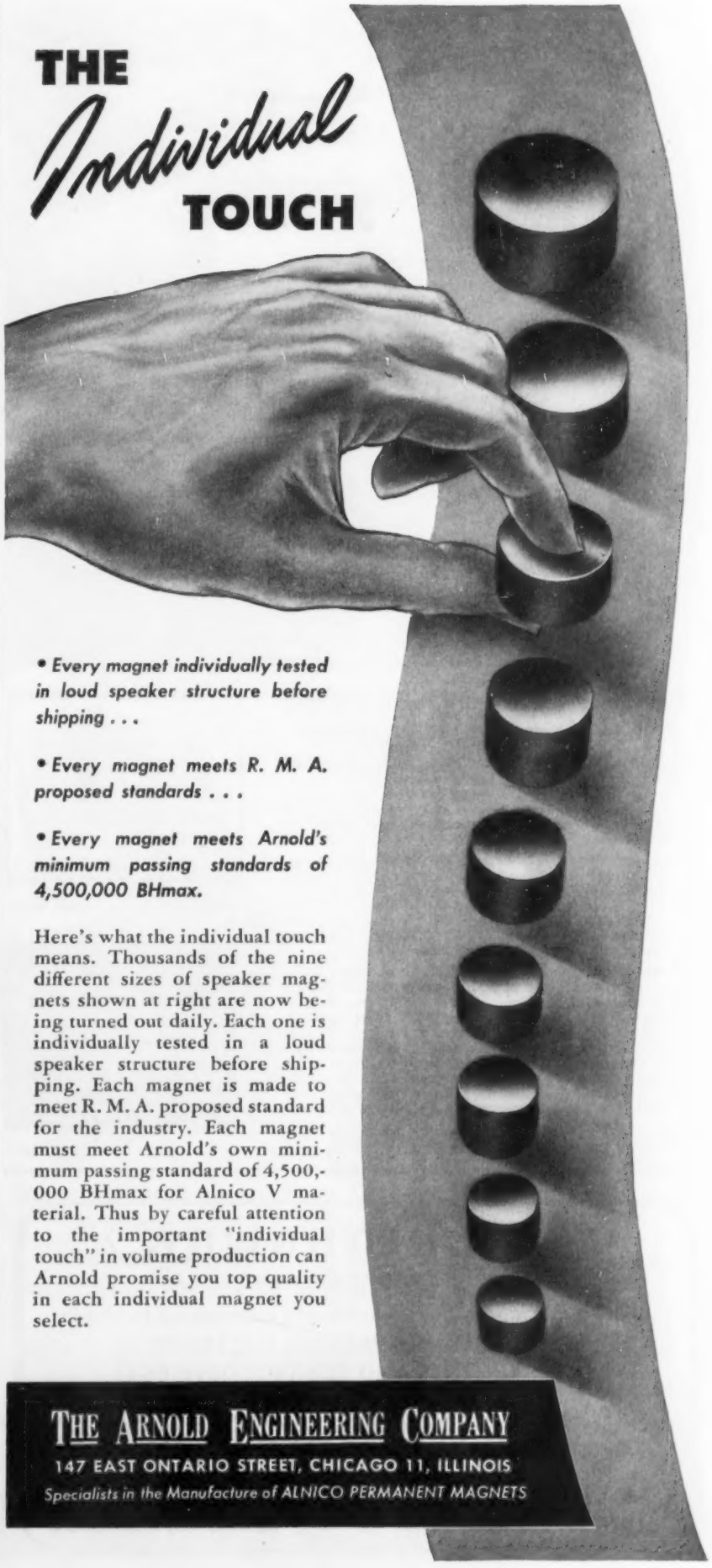
Please mention number 624 when filling out card

Portable Multi-range Voltmeters

New "Type 501" multi-range d-c. voltmeters are said to feature wide versatility, accuracy, and low current drain; and an-



THE *Individual* TOUCH



- *Every magnet individually tested in loud speaker structure before shipping . . .*
- *Every magnet meets R. M. A. proposed standards . . .*
- *Every magnet meets Arnold's minimum passing standards of 4,500,000 BHmax.*

Here's what the individual touch means. Thousands of the nine different sizes of speaker magnets shown at right are now being turned out daily. Each one is individually tested in a loud speaker structure before shipping. Each magnet is made to meet R. M. A. proposed standard for the industry. Each magnet must meet Arnold's own minimum passing standard of 4,500,000 BHmax for Alnico V material. Thus by careful attention to the important "individual touch" in volume production can Arnold promise you top quality in each individual magnet you select.

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Specialists in the Manufacture of ALNICO PERMANENT MAGNETS

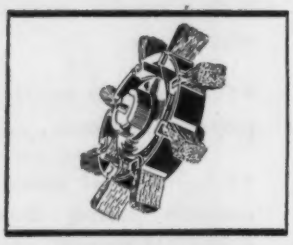
New Brush-Backed, Strip-Fed Abrasive Wheel Deburrs, Sands Any Surface!

For sanding in and around the most irregular contours —for deburring parts too large to be tumbled—for removing rust, paint and imperfections from wood, plastics, rubber, earthenware and metals—the new Sand-O-Flex brush-backed abrasive wheel is MOST PRACTICAL.

The central magazine houses a strip abrasive cartridge, to be fed out as needed in front of the eight brushes which "cushion" the abrasive, and force it evenly over the most difficult surfaces. The Sand-O-Flex comes in 3 sizes, and is adaptable to any stationary or portable motor shaft, with speeds up to 1750 RPM. Abrasives are available in grits for every need.

To help speed production in dry, dusty work atmosphere, many mills and factories urge workers to chew gum to help relieve dry throat. *The reason:* Because dust causes throat irritation and dryness—but chewing Wrigley's Spearmint gum helps keep workers' mouths moist and fresh. *The result:* Reduced work interruptions and "time outs" to the drinking fountain. Even when workers' hands are busy, they can refresh as they work "on the job." And the chewing action helps keep workers alert and wide-awake.

You can get complete information from the Sand-O-Flex Corporation, 4373 Melrose Ave., Los Angeles 27, California



Abrasive Cartridge Shown Open

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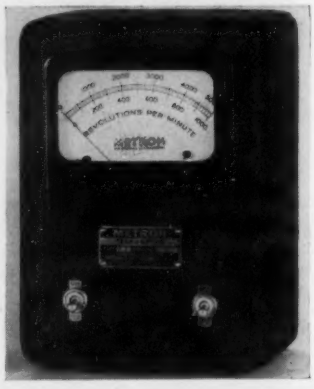
nouncement suggests that one of these instruments will make almost all of the d-c. voltage measurements needed in an electronics laboratory. Ranges: "Type 501F" 0.01-0.03-0.1-0.3-1-3-10-30-100-300-1000 volts full-scale; "Type 501G" 0.1-.3-1-3-10-30-100 volts full-scale. Multiplication of approximately three times between all adjacent ranges makes it possible to use upper two-thirds of scale for all measurements. Resistances are 10,000 ohms per volt for "501F" and 100,000 ohms per volt for "501G," giving extremely low current drain. All resistances are wire-wound for permanent accuracy, with a maximum value of 10 megohms on highest range. Guaranteed accuracy is 0.5%.—*Rawson Electrical Instrument Co., 112 Potter St., Cambridge 42, Mass.*

Please mention number 625 when filling out card

Indicating and Recording Switchboard Tachometers

New complete line of electric switchboard tachometers all utilize contact-making head connected to indicator or recorder by an

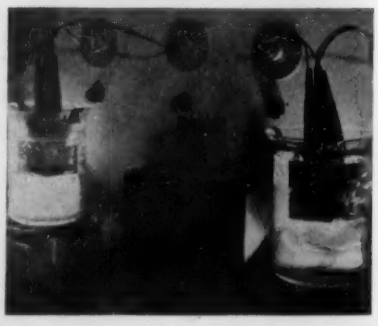


electric cable of any length up to 1000 feet, as described in *Instruments*, Dec. 1945, page 922; May 1946, page 276. Guaranteed accuracies range from 0.25% depending on model. Special limited-range models are available for continuously monitoring specific speeds. Models with multiple heads for monitoring several spindles simultaneously or in succession are available as well as continuously-recording models. A variety of heads is available for fitting any type of machine. Tachometers can be single-range or multi-range. Units for linear speeds as low as 0.25 f.p.m. and for rotational speeds as low as 1 r.p.m. can be supplied on short delivery. Operation is from 115-volt a-c. power line. No vacuum tubes or warm-up required. Units are stabilized against line voltage changes.—*Metron Instrument Co., 430 Lincoln St., Denver 9, Colo.*

Please mention number 626 when filling out card

Tropicalized Selenium Rectifier

New selenium rectifier can be submerged in boiling water or in ice water (as shown in illustration) and still turn alternating current into direct current at an efficiency equal to that obtained under normal operat-

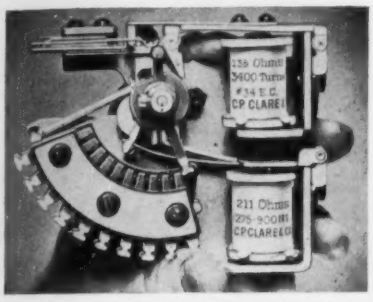


ing conditions, a performance never before achieved with a plate type rectifier, it is said. New rectifier consists of a heavily tin-plated hermetically-sealed container inside which is placed selenium suspended in oil. It will operate with only a slight drop in current output at a temperature higher than 212°F. and will last much in excess of 1,000 hours. It will also withstand salt-spray test which would destroy an unprotected rectifier in a few hours. In tropical areas, insects, fungi and humidity quickly ruin the ordinary open-type rectifier but hermetically-sealed unit is impervious to their attack.—*Westinghouse Electric Corp., East Pittsburgh, Penna.*

Please mention number 627 when filling out card

High-speed Multiple-contact Switch

New "Ten-point, Direct-Drive Stepping Switch with Reset Magnet" is a high-speed multiple-contact switch for the selection of

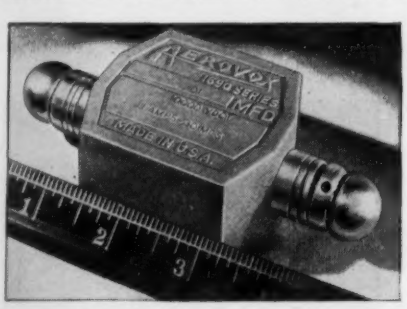


any of ten channels for electrical control purposes. It is supplied with one, two or three bank levels. Overall height is 4½", width 1½" and length (from mounting surface) 3⅝". Maximum operating speed of a 48-volt switch under ideal conditions is 35 steps per second. Release time is 0.03 second. Operating voltages are—Nominal: 6, 12, 24 and 48; Maximum: 8, 16, 32 and 58. Standard finish is cadmium. Net weight is from 13 to 19 ounces, depending upon number of bank levels, off-normal springs, coil windings, etc.—*C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois.*

Please mention number 628 when filling out card

U-h-f. Mica Capacitor

New "Series 1690" molded-in-Bakelite mica capacitor is characterized by exceptionally-low-loss operation at ultra-high-frequencies. Its rounded hardware (round nuts



tightened by spanner wrench, round washers, spherical lock nuts) eliminates sharp edges and corners that cause corona loss. Other features are: use of fine threads for terminal studs for maximum contact; silver plating for all conducting members to minimize skin resistance; body of XM or yellow low-loss Bakelite; internal stack of mica and foil designed for a straight-line path for u-h-f. current. Body dimensions are 2⅝" wide by 2³⁄₁₆" deep by 1⅝" high, and 4¾" overall between rounded terminal tips. Units are available in ratings up to 20,000 volts d-c. test or 10,000 volts operat-

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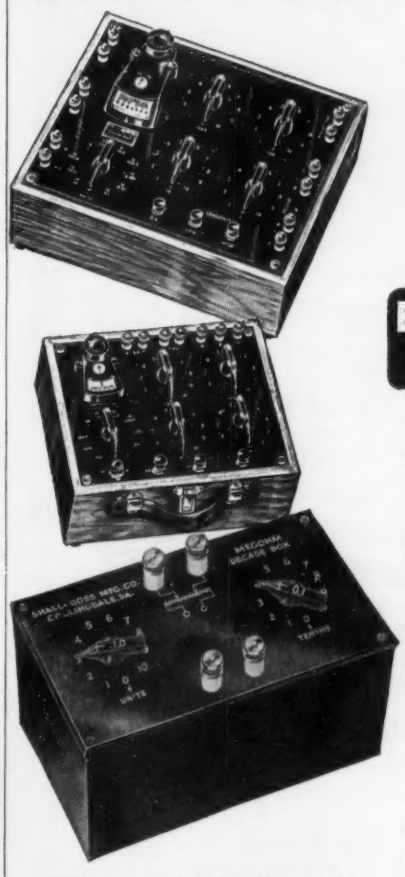

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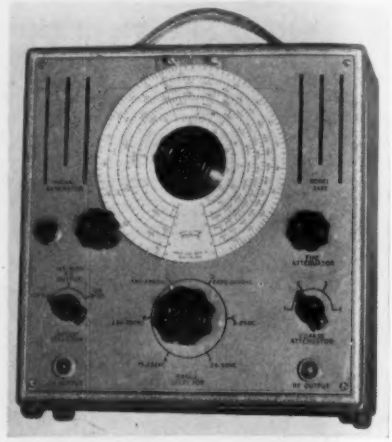
ing, and in capacitance values up to 0.001 μf. at highest voltage rating; can be advantageously applied as blocking capacitors in transmission lines, as tank capacitors for h-f. oscillators, as by-pass capacitors for u-h-f. energy, and as coupling or by-pass capacitors in induction-heating circuits.—*Aerovox Corp., New Bedford, Mass.*

Please mention number 629 when filling out card

Signal Generator

New "Model 2432 Signal Generator" is said to embody several features normally found only in "custom priced" laboratory

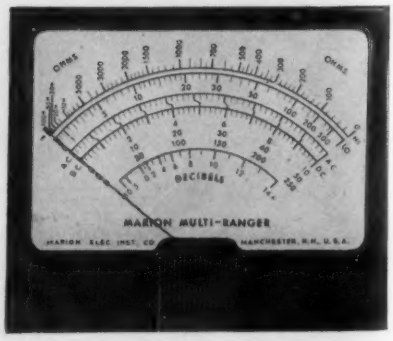


models. Frequency coverage is continuous and overlapping 75 kc. to 50 mc. Six bands. All fundamentals. Turret type coil assembly six-position turret type coil switching with complete shielding. Coil assembly rotates inside a copper-plated steel shield. Entire r.f. and audio assembly enclosed in separate shield. Attenuation individually shielded and adjustable, by fine and coarse controls, to zero for all practical purposes. Stability greatly increased by use of air trimmer capacitors, electron-coupled oscillator circuit and permeability adjusted coils. Internal modulation approx. 30% at 400 cycles. Power supply, 115-volt 50-60-cycle a.c. Voltage regulated for increased oscillator stability. Case is metal with tan hammered enamel finish, brown trim.—*Triplett Electrical Instrument Co., Bluffton, Ohio.*

Please mention number 630 when filling out card

Multiple-range Electrical Tester

New "Multi-Ranger" is described as a new foundation instrument designed to "permit user to assemble a highly accurate in-



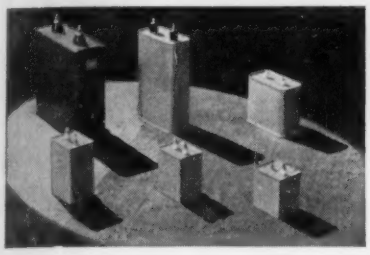
strument" for use as a voltmeter, milliammeter, high- and low-resistance ohmmeter, a-c. voltmeter and decibel meter. "Multi-Rangers" are available in 3½", 4½" and 8½" sizes and each size is interchangeable electrically. Basic sensitivity of instrument is 400 microamperes and internal resistance

is 500 ohms, ±1%. Alnico magnets are used, with new "Bulldozer" moving system. Scales are printed in three colors for quick identification and cover 100°. With proper switching arrangements all voltmeter and ohmmeter features can be incorporated in one piece of equipment. Scale ranges normally supplied include: 0-10-50-250 d-c. volts, 0-10-50-250 a-c. volts, 0-500 ohms and −10 megohms, −10 to +14 db. By use of proper multiplier, 0-10 voltmeter scale can also be used as 0-1000 volts. Scales are printed in red, black and green. Circuits supplied with each instrument provide clear instructions for construction of single- or multi-range equipment; all component values are shown on circuits.—*Marion Electrical Instrument Co., Manchester, N. H.*

Please mention number 631 when filling out card

Energy Storage Capacitors

New line of small, lightweight, d-c. Pyranol capacitors is for use in flash-photography apparatus, light-metal welders, and



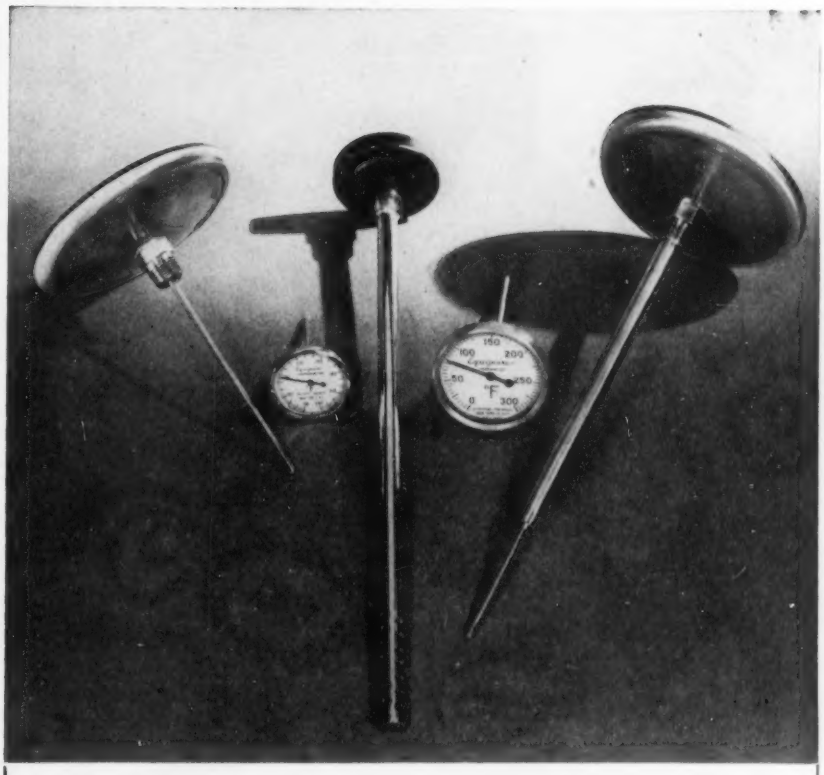
similar applications requiring economical energy storage, fast discharge, and over-all reliability. Units are available in a wide range of ratings, with ambient temperature operating limits at rated voltage ranging from 0 to 50°C. and capacitance tolerances at 25° ±10%.—*General Electric Co., Schenectady, N. Y.*

Please mention number 632 when filling out card

Wide-band Video Amplifier

New all-purpose wide-band video amplifier, capable of meeting exacting requirements of television, radar, and other in-

dustrial applications, is designed for use as an oscilloscope deflection amplifier for the measurement and viewing of pulses of extremely short duration and rise time. Amplifier is supplied in a portable cabinet 19¼"×22"×14¾", and consists of amplifier unit, a low-capacity probe and a power unit. Amplifier has a gain of 120 (41.5 db) and is flat within ±1½ db from 100 c.p.s. to 20 Mc. Input impedance, using the probe, is 30 mmf. across 4.7 megohms and at the input jack it is 30 mmf. across 470,000 ohms. Output is push-pull and output impedance is 18 mmf. across 5000 ohms each side. Output voltage is 56 volts peak-to-peak, push-pull. Amplifier has a frequency-compensated attentuator calibrated in 10-db steps from 0 to 50 db. A fine attenuator control is provided to cover a range of 10 db.



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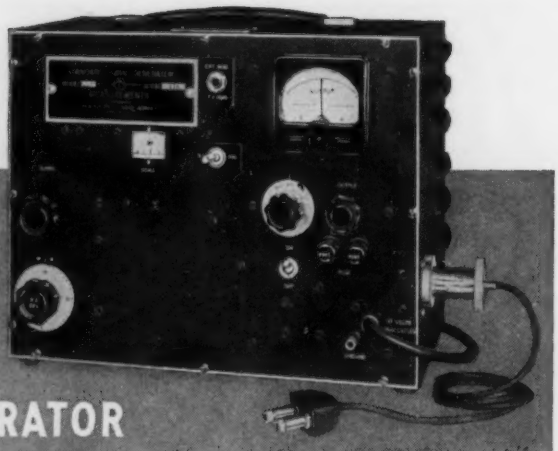

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MODEL 78
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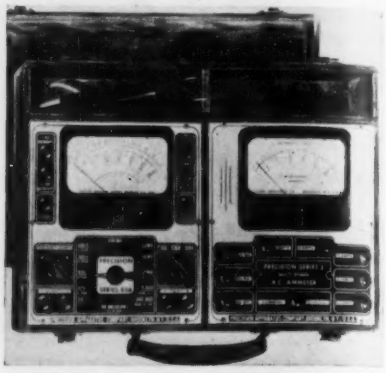
Instrument is completely shielded; and output terminals are located on right side of cabinet and serve to minimize lead length and capacitance to oscilloscope.—*Polarad Electronics Co., 135 Liberty St., New York 6, N. Y.*

Please mention number 633 when filling out card

Industrial Circuit Tester

New mulit-range a.c.-d.c. "Series 856-J Industrial Circuit Tester" is for use in industrial, eléctric power, laboratory testing



and analysis; as well as for use in school and university labs. It is a unit combination of "Series 856" and "Series J" said to provide an exceptionally wide selection of 52 a.c.-d.c. voltage and current ranges. A-c. unit incorporates an internal heavy-duty current transformer designed for operation on 25 cycles and higher. Two 4½" full-vision indicators are provided. The "856" has 50-ma. full-scale sensitivity and provides calibration at both 20,000 and 1,000 ohms-per-volt at the flip of a switch. New combination makes possible simultaneous measurements of alternating current and voltage with independent readings on separate dials. Accuracy is 3% on a.c. amperes, 5% on a.c. voltage. Equipment is furnished in a portable hardwood carrying case, with tool compartment and hinged removable cover. Overall size: 11×15×6". Supplied complete with ohmmeter batteries and extra high voltage super-flex test leads. —*Precision Apparatus Co., Inc., 92-27 Horace Harding Blvd., Elmhurst, N. Y.*

Please mention number 634 when filling out card

Automatic Radio Compass and Loop

New light-weight automatic radio compass has its loop antenna housed in a transparent extremely-light-weight plastic "bubble." New loop is smallest ever produced (4" diam.) yet is said to have "greater sensitivity than the larger loops now in general use." Transparent plastic "blister" is streamlined so effectively that when installation was tested on maker's Model 18 Beechcraft "flying laboratory," it showed only 0.6 lb. drag at 180 m.p.h. Combined weight of ARC loop and housing is 1.3 lbs. installed. One of innovations is use of a Lear servo unit to rotate loop automatically to null position when tuned to any partic-

ular station. This servo, said to be exclusive Lear design, is a combination dynamotor, power supply, and gear attachment with a novel clutch arrangement.—*Lear, Inc., 110 N. Ionia Ave., N. W., Grand Rapids 2, Mich.*

Please mention number 635 when filling out card

Frequency Calibrator

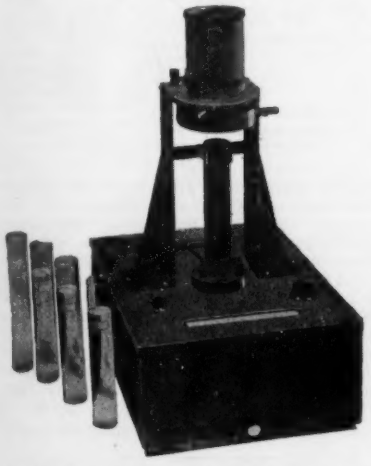
New "Model RH-10 Frequency Calibrator" allows full use to be made of world's finest frequency standards transmitted from

radio station WWV: it is pre-tuned for 5 and 10 Mc., either selected at will. Provisions are made for coupling secondary standards or other r-f. sources and comparing their fundamentals or harmonics with the standard frequencies transmitted by WWV. A cathode-ray indicator permits frequency comparisons to be made to at least 1/10 cycle. A dual filter, for selection of either 440- or 4000-cycle modulation, allows these frequencies to be employed as a primary standard. Sensitivity of "RH-10" is better than ½ microvolt and image rejection ratio is more than 50 db. "RH-10" is supplied in a cabinet as shown or rack mounting with dust cover. Dimensions: 9"×19"×11". Weight: 30 lbs.—*Browning Laboratories, Inc., Winchester, Mass.*

Please mention number 636 when filling out card

Photoelectric Colorimeter for Nessler Tubes

New "Model 450 Lumetron Photoelectric Colorimeter for Nessler Tubes" is designed particularly for the measurement of faint



colorations and turbidities. It is suited for the trace analysis of water, metals, soil extracts, and any other determinations in which only a comparatively slight coloration can be developed. It is also suited for color grading of lightly-colored liquid products. No glass or liquid standards are required for the measurement of samples. In quantitative analysis, it is only necessary to establish once the calibration for the determination in question, using solutions of known concentration. This calibration then serves in all subsequent routine tests, to translate transmission readings of unknowns into their concentration values. When "Model 450" is used for color standardization rather than for chemical analysis, it is mostly not even necessary to establish a

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549	1.07	1.42	3.84	6.14	15.35c
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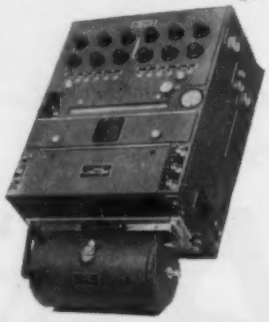

Available in three types. Type S8-B, right. Type S9-C same as Type S8-B except with 24 to 36 elements. Type S8-D, same as Type S8-B, but minus automatic control features.

Write for information. Bulletin SP-165 for Types S8-B and S8-C. Bulletin SP-175 for Type S8-D.

Hathaway Instrument Company, 1315 S. Clarkson St., Denver 10, Colorado.

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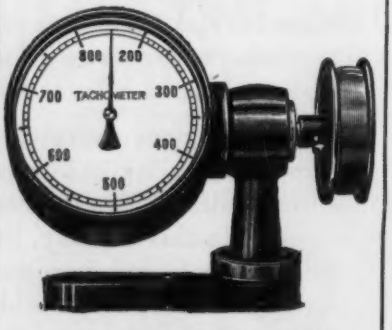

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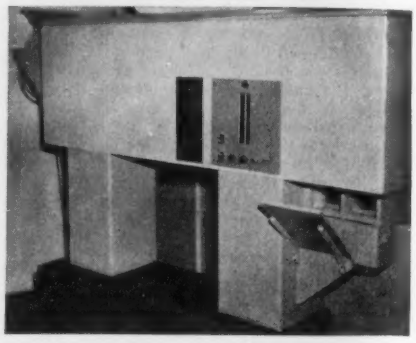
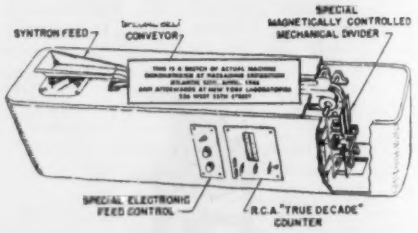
calibration inasmuch as transmission values obtained can be interpreted directly as color. However, when user wishes to report results in terms of established color scales, it will be found easy, in most instances, to correlate transmission readings with the color scale. "Model 450," if not specified otherwise, can be operated either from 105-125 volt 60-cycle power line or from a storage battery of the automobile type. Special models are available which, in addition to battery operation, permit operation from 50-cycle or from 25-cycle a-c. lines. 220/110 volt step-down transformers are available. Instrument can also be furnished for battery operation only. Built-in stabilizing system gives satisfactory stability of readings even where voltage of power line is subject to considerable fluctuations. —*Photovolt Corp., 95 Madison Ave., New York 16, N. Y.*

Please mention number 637 when filling out card

Automatic Feeder-counter-dispenser

New "High-speed Electronic Dispenser" for manufacturers of tablets, pills, buttons, screws, cigarettes, candy, plastic parts, etc.,



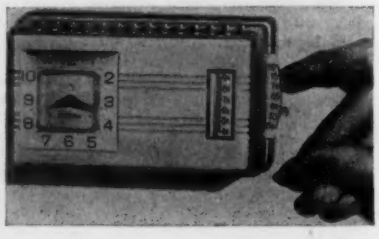


comprises mechanical and electrical means of feeding, counting and dispensing the items to alternate packaging positions. (Automatic packaging equipment can be synchronized to form an integrated counting and packaging system.) It employs an RCA highspeed, selective, electronic counter as a means of counting the products, is capable of handling sizes from 3/16" to ⅝" at speeds up to 100 per second. Items of larger sizes can be handled with special adaptations.—*Raymond M. Wilmotte, Inc., 236 West 55th St., New York 19, N. Y.*

Please mention number 638 when filling out card

House Thermostat

New "1947 Chronotherm" completely automatic thermostat, said to make use of many war-born developments, will supplant



all pre-war models. Time settings for day and night temperatures, on a new quarter-hour interval scale, will permit fuel savings or 10 to 30% depending upon home construction, occupancy, and other factors. Instrument makes use of a new-type bimetal element developed for it. An additional electrical mechanism prevents overshooting day-time temperature setting during morning pick-up. Self-starting clock employs a low-speed motor to eliminate noise, can be adjusted as easily as a watch. A locking cover, available if desired, prevents unwanted tampering with clock, dial settings or internal mechanism. New feature provides temperatures down to 50°F. while occupants of a home are away for a weekend or longer.—*Minneapolis-Honeywell Regulator Co., Philadelphia. Pa.*

Please mention number 639 when filling out card

Photo-flash Units

New portable electronic photo-flash equipment for amateur and professional photographer uses a flash bulb filled with xenon

Fig. 1

"as compared with the ordinary oxygen filled flash bulb," and takes up to 10,000 exposures with one flash lamp. It is the approximate size and weight of a professional camera. (See Fig. 1.) It employs two Raytheon CK-1013 cold-cathode high-voltage rectifier tubes. It also has a small battery, an auto radio vibrator and a flasher tube which gives off the light necessary to take a photograph. (A slightly larger model will operate from 110-volt a-c. supply.) Vibrator transforms d-c. battery voltage to a.c. which is stepped up in voltage through a transformer to several thousand volts. This high voltage is rectified by the CK-1013 tubes which charge capacitor; is then discharged through the flash lamp at instant that picture is taken. A cable connects photo-flash unit to camera and flash bulb. Among advantages claimed: (1) eliminates inconvenience of carrying supply of flash bulbs and constantly changing them; (2) many more pictures per minute; (3) clearer

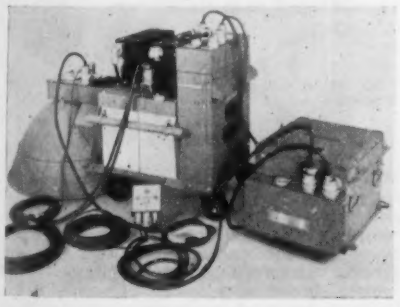
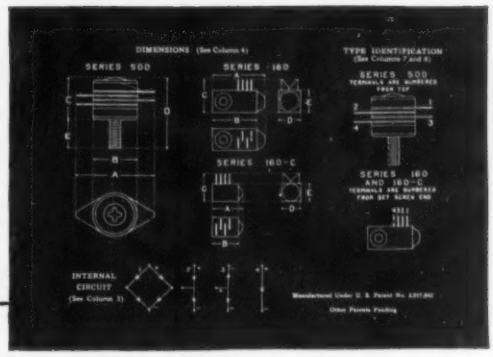


Fig. 2

Conant Instrument Rectifiers



SPECIFICATIONS (STANDARD TYPES)

Col. 1	2	3	4					5	6	7	8				9						10
											Color, Terminal Number				PEAK ELECTRICAL RATINGS						
		Internal	Dimensions (Inches)					Mounting Screw	Weight	No. of Terminals					Instantaneous		Intermittent		Continuous		*List
Type	Series	Circuit	A	B	C	D	E	Size	(Grams)		1	2	3	4	Volts	Mils	Volts	Mils	Volts	Mils	Price
M	500	1	.890	.500	.485	.800	.328	6-32	13.012	4	red	no	blk	no	30	100	20	60	10	30	$3.50
HS	500	2	.890	.500	.445	.800	.360	6-32	9.158	3	red	no	blk	—	15	100	10	60	5	30	2.70
T	500	3	.890	.500	.445	.800	.360	6-32	9.158	3	no	red	no	—	30	100	20	60	10	30	2.70
H	500	4	.890	.500	.400	.800	.392	6-32	7.730	2	red	no	—	—	15	100	10	60	5	30	1.50
B	160	1	.595	.485	.375	.250	.250	2-56	3.400	4	red	no	blk	no	30	15	20	10	10	5	3.50
BHS	160	2	.625	.550	.375	.250	.250	2-56	2.880	3	red	no	blk	—	15	15	10	10	5	5	2.70
BT	160	3	.625	.550	.375	.250	.250	2-56	2.880	3	no	red	no	—	30	15	20	10	10	5	2.70
BH	160	4	.625	.550	.375	.250	.250	2-56	2.700	2	red	no	—	—	15	15	10	10	5	5	1.50
B-C	160-C	1	.345	.297	.310	.220	.200	none	1.743	4	red	no	blk	no	30	15	20	10	10	5	3.50
BHS-C	160-C	2	.345	.297	.310	.220	.200	none	1.385	3	red	no	blk	—	15	15	10	10	5	5	2.70
BT-C	160-C	3	.345	.297	.310	.220	.200	none	1.385	3	no	red	no	—	30	15	20	10	10	5	2.70
BH-C	160-C	4	.345	.297	.310	.220	.200	none	1.293	2	red	no	—	—	15	15	10	10	5	5	1.50

Over ninety per cent of all rectifier requirements are served by 12 types—4 basic assemblies in 3 series. These 3 series are the three primary units of Conant rectifiers. Special types, however, can be developed as needed, and you'll find Conant ready to cooperate.

SERIES 500 UNITS are for general applications requiring greater output current for meters, relays or other apparatus requiring more than 1 milliampere. Recommended for all such applications at commercial and the lower audio frequencies. Will also operate up to 50,000 c.p.s. in special applications wherein accuracy of readings is not essential.

SERIES 160 and 160-C are for applications requiring good frequency response over the entire commercial and audio range and especially when the meter, relay or other apparatus requires less than 1 milliampere for operation. In some special applications these units may be operated at frequencies up to 15,000,000 c.p.s. with special circuit treatment.

SPECIAL TYPES are available in both series 500 and 160-C. When requesting a quotation on a special type include a sketch of the rectifier required or a circuit diagram showing source and frequency of the input voltage, resistance and kind of load, required load current and the ambient temperatures.

SERIES 500 Disc diameter .500 inch. Area each disc .15 square inch. Furnished with 3" braided, tinned copper leads. Finished in clear lacquer. Nickel plated end plates.

SERIES 160 Disc diameter .160 inch. Area each disc .02 square inch. Furnished with 3" stranded, tinned double silk covered copper leads. Nickel plated case. Assembly sealed with specially developed moisture proof compound.

SERIES 160-C Disc diameter .160 inch. Disc area, lead wire and length and moisture proof seal are identical with Series 160. Dimensions of the nickel plated case have been reduced to the most compact size. These units may be mounted in a standard midget fuse clip.

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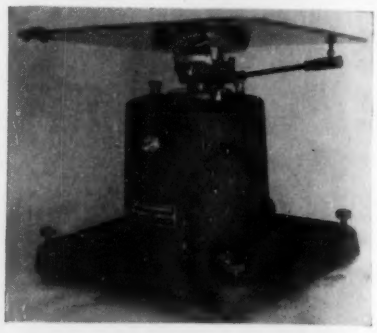
shots of high-speed action because of short duration of flash; (4) more life-like color pictures because light from the xenon-filled lamp is more comparable to daylight; (5) saving in cost because of long life of flash bulb. This new photo-flash equipment for commercial use is an outgrowth of maker's aerial photo-flash equipment for Army and Navy. This equipment (one model shown in Fig. 2) is designed for aerial night photography, making possible "sneak camera attacks" on enemy territory, some models producing a flash lasting 1/10,000 second at a light intensity of 80 million candle power.—*Raytheon Mfg. Co., 60 E. 42nd St., New York 17, N. Y.*

Please mention number 640 when filling out card

Testing Table for Gyro Aircraft Instruments

New "No. 1406R Oscillating Table" subjects aircraft gyroscopic instruments to combined motions of roll, pitch and yaw which

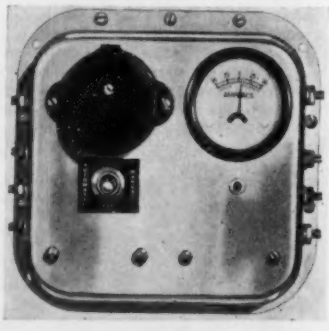


cause every bearing and pivot in instrument to be in motion, thereby permitting easy detection of any trouble caused by rough, sticky or imperfectly-adjusted bearings. Synchronous driving motor operates on 110-volt 60-cycle a-c. supply, rotates at 75 r.p.m. and, through one compound gear, drives head at 6 r.p.m. (standard rate, others special). Reversing is at will, or automatic every 6 cycles. Tilt angle is adjustable from 0° to 15°. Bench space required, 10″ × 10″. Table height, 9″. Various instrument-mounting adapters are supplied. —*Ideal Laboratory Tool and Supply Co., 3619 Evans Ave., Cheyenne, Wyoming.*

Please mention number 641 when filling out card

Starting Panel for Gasoline Engines

New automatic starting panel for gasoline-engine-driven refrigeration compressors and pumps may be controlled by any



2-wire pressure, temperature, float or manual control device. It closes ignition circuit and energizes engine-starting solenoid when control device closes, and de-energizes engine-starting solenoid after engine fires and generator approaches rated voltage. When control device opens, control panel opens ignition circuit, thus stopping engine. Panels are built to customer's requirements

with standard automotive magnetic and manual electrical controls. Auxiliary devices such as engine-starting solenoids, reverse current contactors and voltage regulators are also available for complete electrical control installations. Panel is available with cranking time limiter and cranking interrupter to provide several starts. Hand reset cranking time limiter stops cranking cycle in approx. 1 minute should engine fail to start.—*R-B-M Division, Essex Wire Corp., Logansport, Indiana.*

Please mention number 642 when filling out card

Headloupe

New "Model 502 Super Sight Headloupe" is supplied with a lens system in either of two powers; 1¾ diopter, 13" focal length;

2½ diopters, 9" focal length. Worn with or without glasses, it is supplied with an engenious bracket permitting lens system to be set in any position for ease of operator: in or out, up or down, or pushed up out of vision when not needed. Completely adjustable bracket is important in industries and professions where depth perception (third dimension) together with good magnification are vital. Both hands are free for work. Back headband is of fiber, adjustable by a knurled nut with a right and left hand thread to provide a full point floating suspension that can be worn over long periods of time without fatigue. Lens holder also acts as eye shade.—*The Boyer-Campbell Co., 6540 St. Antoine St., Detroit 2, Mich.*

Please mention number 643 when filling out card

Torque Screw Drivers

New "Tru-Torque" torque measuring and controlling screw drivers are of friction-disk type claimed by manufacturer to be

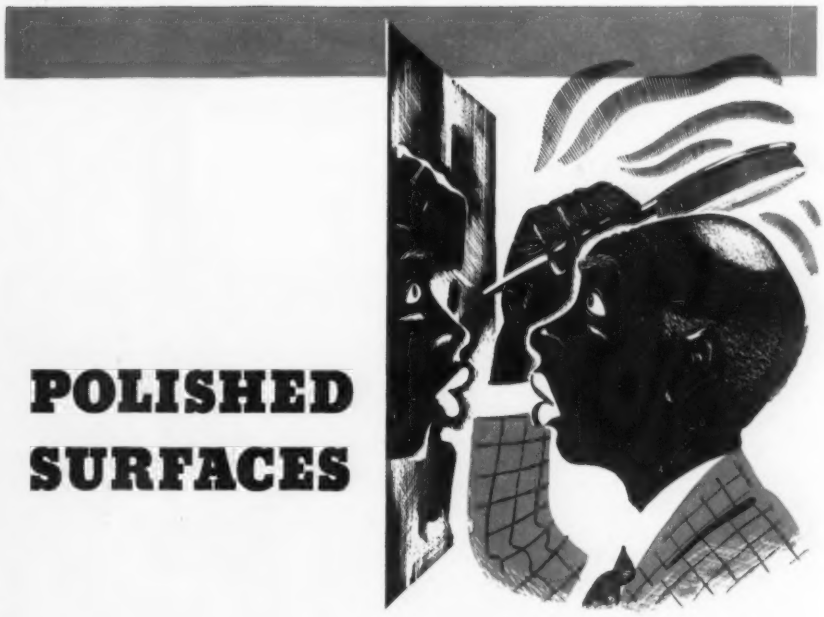
"the most accurate principle of torque measurement and control," are manufactured in three standard sizes:

(1) Small, from 0 to 6 in.-lb.;
(2) Medium, from 0 to 12 in.-lb.;
(3) Large, from 0 to 25 in.-lb. Operation is simple: screw driver is pre-set at desired torque; operator tightens screw, nut or bolt; when predetermined torque is reached the screw-driver handle slips and no further tightening of the screw is possible. "Tru-Torque" screw drivers come complete with one regular blade for slotted screws, nuts or bolts, one Phillips-type blade, one Allen wrench and pin setter. Snap-on adapter is available also.—*Airdraulics Engineering, Inc., New Canaan, Conn.*

Please mention number 644 when filling out card

Three-sense Torque Wrenches

Four new models are added to maker's "Sensory" line of torque wrenches. They are as follows: "Model S200" having capacity 0 to 200 foot-pounds, calibrated in 5-ft.-lb. steps; "Model S300" having capacity 0 to 300 ft.-lbs., calibrated in 10-ft.-lb. steps:



One thing about highly polished surfaces — it takes them a long, long time to wear out, even with constant rubbing.

That's one reason why a Helicoid Pressure Gage was still going strong — still accurate to 1/2 of 1% — after 75,000,000 cycles. The movement consists of a polished graphited bakelite cam sliding in a highly polished helical groove. This instead of the conventional spur gears.

There is ample proof that a Helicoid Pressure Gage will remain accurate many times longer than any spur-geared movement gage ever made. This is important if you use pressure gages in any quantity.

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Eliminate product failures and rejects caused by warping, stripping or undertightening of screws, bolts and threaded parts. Insure the complete performance of your products by speedy assembly with Sturtevant Sensory Torque Wrenches.
Far faster than other production Torque Wrenches (because operation is by automatic reflex-action), Sensory Wrenches are infallibly accurate, for accuracy too is automatic.
World's largest manufacturer of Torque Wrenches—31 capacities.
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ADDISON QUALITY ILLINOIS

"Model S2400-I" having capacity 0 to 2400 inch pounds, calibrated in 50-in.-lb. steps; "Model S3600-I" having capacity 0 to 3600 in.-lbs., calibrated in 100-in.-lb. steps. These four models are equipped with ¾" drive squares. Up to now, "Sensory" line has been furnished in 25, 50, 100-ft.-lb. and corresponding in.-lb. capacities. Name "Sensory" was given because, as fully described in *Instruments*, Oct. 1944, page 630, wrench permits measurement of pre-set torque by sight, sound and feel.—*P. A. Sturtevant Co., Addison, Illinois.*

Please mention number 645 when filling out card

Exposure Meter for Use with ASA Film-rating System

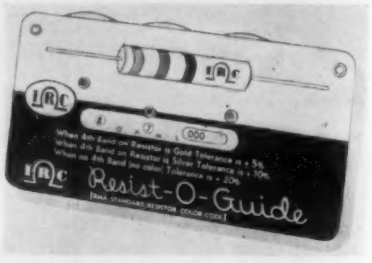
New modified form of "DW-58" exposure meter incorporates new American Standards Association exposure-index numbers,

being adopted by nation's leading film manufacturers for all classes of users. Numbers in ASA system are so arranged that they are close enough to permit their use with all previous model G-E exposure meters with minimal difficulty.—*General Electric Co., Schenectady, N. Y.*

Please mention number 646 when filling out card

Resistor Identifying Device

New "Resist-O-Guide" is a pocket size aid in resistor range identification for electrical designers. It is used by turning its three wheels to correspond with color code on any composition type resistor: standard



RMA range is automatically indicated. Conversely, if wheels are turned to indicate desired standard range, device shows correct color coding. "Resist-O-Guide" is available at IRC distributors.—*International Resistance Co., 401 N. Broad St., Philadelphia, Penna.*

Please mention number 647 when filling out card

Lens Coating Process

New "Acra-Cote" high-vacuum lens coating process eliminates ghosts and flares, improves color rendition of industrial photographs is being applied to lenses used in cameras, projectors and enlargers, has been adopted by Paramount, Walt Disney Productions, Scientific Films, RKO, Howard Hughes, Goldwyn, Columbia, and other m-p.

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Now available to 35,000 VOLTS
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studios. It is also being applied to gunsights, microscopes, binoculars, and other optical instruments.—*Acra Instruments, 6650 Sunset Blvd., Hollywood 28, Calif.*

Please mention number 648 when filling out card

Miniature Magnifier

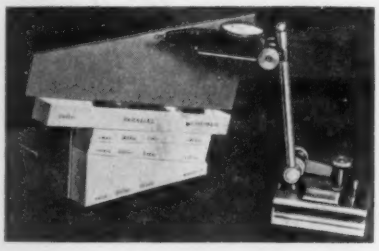
New "Mini-Mag" miniature magnifier measures 1¼" wide by 2¼" long, weighs ¾ oz. Announcement claims that "for the

first time in a miniature magnifier" lens is rectangular in shape so as to give a much larger field of vision than is usually obtained in a magnifier of similar size. Lens is ground from finest optical glass obtainable, is plano-convex so that by holding the convex side up, distortion and aberration are eliminated and a clear sharp flat field is obtained from edge to edge. "Mini-Mag" has a magnification of 1½ but because of its extreme clarity and lack of distortion, and the fact that convex side is ground to ten diopters, is said to be "twice as powerful in magnification as any other hand magnifiers on the market that are two, three, and even four times larger."—*Edroy Products Co., 480 Lexington Ave., New York 17, N. Y.*

Please mention number 649 when filling out card

Angle Gage Blocks

New "Webber Angle Gage Blocks" are guaranteed accurate to within 1/5, 184,000 part of a circle, will yield any angle from



0 to 103° in steps of one second of arc. Working surfaces being optically flat, blocks wring together as do ordinary gage blocks. For example, to obtain an angle of 12°, take the 3° and 9° blocks and wring them together with the large ends marked "plus" adjacent. To obtain an angle of 6°, take the same two blocks and wring them together with "minus" end of one adjacent to "plus" end of the other. Two or more may be wrung together to produce any angle in degrees. "Webber Angle Gage Blocks" are furnished individually or in three sets. Set No. 14-A, range: 0 to 103° in 1-second steps making at total of 370,800 angles; Set No. 10-A, range: 0 to 103° in 1-minute steps (6180 angles); and Set No. 6-A, range: 0 to 103° in 1° steps (103 angles). —*Webber Gage Co., 12904 Triskett Road, Cleveland 11, Ohio.*

Please mention number 650 when filling out card

Dark Field Quebec Colony Counter

New Dark Field Quebec Colony Counter is styled to conform with modern laboratory instruments, cool to operate, and sturdily built of sheet steel. Front surface is in-

REGULATED POWER SUPPLY
250-450 VOLTS
Wide fields of application have been opened up both in research and industry for this unit. A-C ripple is negligible and extreme care has been taken to eliminate high-frequency noise. Regulated power supply units are invaluable for such applications as amplifiers, television pulse generators, constant frequency oscillators, and measuring equipment.
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PREDETERMINED
ELECTRONIC
COUNTER
A time and money-saving instrument
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• For accurate control of length and spacing of slide fasteners.
• For use in automatic packaging of objects such as buttons and pills.
• And for many other operations throughout industry.
This instrument uses three to four standard Potter 4-tube counter decade circuits arranged to give two independent predetermining channels in which any number, from 0 to 10,000, may be initially set up. Each channel is alternately pre-set to the desired predetermined number by automatic, self-contained circuits at a speed not obtainable with predetermined mechanical counters. The input is arranged for operation with either make-contacts or sharp negative pulses. Input frequencies may be in excess of 1000 cycles per second. The output includes an ultra-high speed relay with single pole double throw contacts. The standard unit may be ordered for a total count capacity of 1000 to 10,000 with either the single or dual predetermining channels. Other count capacities on special order. Write for additional details.
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FLUSHING, NEW YORK

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At a glance, the face of this CORBIN Tachometer will tell you the number of TONS PER HOUR, TONS IN BATCH and TOTAL TONS up to that time. Whether you're counting tons or cases, bottles, bales . . . or measuring in lengths, or counting revolutions . . . Corbin can engineer a Corbin Tachometer to meet your requirements.

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Corbin Screw Division
American Hardware Corp.
New Britain, Connecticut

PA-3

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Rubicon Wheatstone and Kelvin Bridges are available in a number of types to suit various applications. All are made in accordance with the highest traditions of the instrument maker's art and are fully guaranteed.

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clined at an angle most convenient to average technician; but an auxiliary tilting base can be supplied for further adjustment. Scientifically designed reflector provides glareless illumination, uniform over entire field and adequately bright to reveal and distinguish small colonies from other structures. Emphasis has been laid on correct illumination to facilitate counting and to reduce fatigue. The 4½" lens mounted on a sliding rod for focusing has standard 1.5× magnification specified by American Public Health Association; is so positioned that errors from parallax are avoided. If required, additional magnifications can be provided by addition of an auxiliary lens. When not in use, lens and mount may be pushed down and out of the way. Wolff-hiegel, Steward and Jeffers guide plates are available. Centering screws are provided so that a petri dish may be positioned when circular ruled plates are used.—*Scientific Instrument Div., American Optical Co., Buffalo 11, N. Y.*

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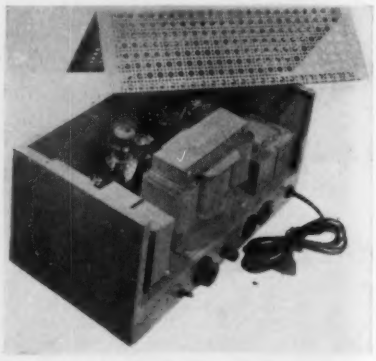
Voltage Regulator

Newest addition to maker's line voltage regulators is "Model 500," designed for low-cost applications. It will maintain output

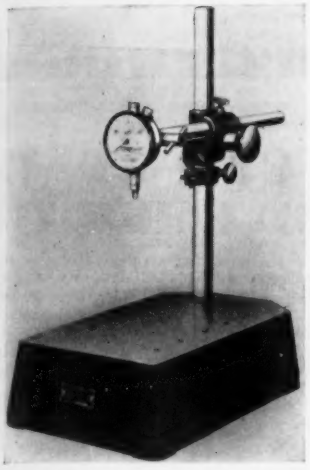


voltage within ±0.5% of adjusted value during variations of input voltage from 95 to 125 volts and variations in load from 50 va. to 500 va. Regulation is accomplished by electronic means, without moving parts. Transient recovery time is approx. four cycles. Unit functions independently of frequency variations of as much as 10% and has harmonic distortion of less than 5%.—*Sorensen and Company, Inc., Stamford, Conn.*

Please mention number 652 when filling out card

Dial Comparator

New "Model 107" dial comparator is suited to a wide variety of uses by reason of extensible indicator support arm and tapped holes in platen for securing the



work. Any dial indicator having a standard AGD lug type back may be used. By means of a double clamp arrangement, indicator support arm may be slid up or down on vertical column, swung to any angle in either a horizontal or vertical plane, and moved to place indicator at desired distance from column. Setting is facilitated by a vernier screw. Friction washer concealed in swivel prevents indicator arm from dropping unintentionally when clamp is loosened for adjustment. Working area of platen is 6"×9". Five tapped holes on either side are spaced 1½" and will receive ¼"-20 bolts for securing the piece being checked.—*Standard Gage Co., Poughkeepsie, N. Y.*

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Controlled-conditions Cabinet for Climate Tests

New "Aminco Climatizer" produces in laboratory test chambers and small-size rooms the average temperatures and humidities that prevail in most countries of

the world. It can be used as an individual unit for application to a test chamber already in customer's laboratory, or it can be supplied with an "Aminco Work Chamber" as shown in illustration. It is claimed that extreme sensitivity and immediate response of humidity-controlling portion of "Climatizer" are made possible by the use of highly-sensitive controls. No centrifugal atomizers or spray devices being used within work chamber to maintain humidity, use of drip pans is eliminated. Necessary amount of water in "Climatizer" itself being maintained automatically, manual filling with water buckets or bottles is unnecessary. Another feature is extra-length heaters totally enclosed in protective metal sheaths. A large section of top of "Climatizer" may be lifted off for inspection of interior.—*American Instrument Co., Silver Spring, Md.*

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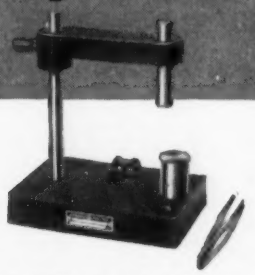
Magnetic Hardness Tester



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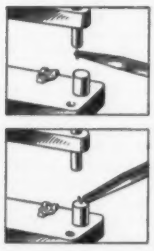
This new G-E tester simplifies inspection of such parts as electric instrument pivots, watch shafts, small steel balls, and many others. Operation is based upon the correlation of hardness and coercive force in magnetic materials. There are no scales to read; a direct "go—no go" test. Does not damage the tiniest specimen. Checks irregularly shaped pieces whose longest dimension is between 1/16 and 1/2 inch.



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STEP 1—Part to be tested is magnetized by touching it to magnet. STEP 2—Part is placed at center of anvil. If its hardness equals, or exceeds, the standard, the part remains upright; otherwise it falls down. Write for leaflet GEA-4544. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

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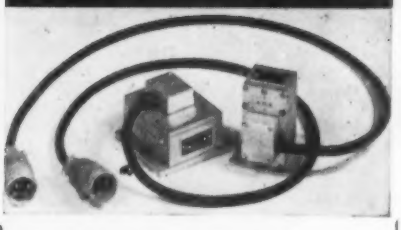

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Instrument SOCIETY OF AMERICA

CLEVELAND

The Cleveland Section, ISA, met the evening of May 22nd at the Cleveland Engineering Society. Twenty-two members were present for dinner and approximately fifty for the meeting. Mr. John F. Ireland, Sales Manager for the Sapphire Products Division of the Elgin National Watch Company presented a sound and color film entitled "Jewel Bearing Manufacture." This picture illustrated the manufacturing processes of sapphire jewel bearings used in watches and precision instruments. Following the film Mr. Ireland presented a slide talk "Sapphire—An Engineering Material." This talk brought out the comparison between manufactured and natural mined sapphire; the method of manufacture of sapphire; the importance of orientation of the crystal in design; the geometry of fabrication from an irregular raw material shape; the methods and machines used in fabricating sapphire; charts on hardness comparisons; physical and chemical properties; comparative wear resistance in gage applications; and details of sapphire plug and ream gages, contact points, tip micrometer, etc.

The interest in this subject was quite high as evidenced by the active question and discussion period.

Election and installation of new officers for the coming year followed. Results: Samuel Bousky (Jack & Heintz), President; Henry E. Schauss (Arthur G. McKee & Co.), Vice President; Joseph A. Prada (Alcoa), Treasurer; and A. J. McCullough (Brown Instrument), Secretary.

—A. J. McCULLOUGH, *Secretary*

CUMBERLAND, W. VA.

The Cumberland Section of The Instrument Society of America held a dinner meeting Tuesday, May 28, at the Queen City Hotel.

Mr. Otto Kneisel delivered a lecture on Diaphragm Control Valves in the absence of Bruce Irwin who was unable to attend. For the last three years Mr. Kneisel has been doing Valve Development work for the Hammel-Dahl Company of Providence, Rhode Island. He was accompanied by Mr. Wayne B. Farley, District Sales Manager of the Hammel-Dahl Co.

—H. E. BISHOP, *Chairman, Publicity Com.*

DETROIT

At the May meeting of the Detroit Section, ISA, relatively new techniques involving the use of wire strain gages were explained by Mr. C. H. Gibbons, Application Engineer of the Baldwin-Southwark Division, Baldwin Locomotive Works. He mentioned several war-developed applications of these little wires which played so large a part in the attainment of victory; the versatility of strain gages became evident in the description of such widely differing uses as the measurement of deformations caused by hammer blows on the skulls of dogs (to study brain concussions encountered in tank and air warfare) and the measurement of residual stresses in the huge plates of Liberty ships using hundreds of gages on one plate.

The audience of 85 engineers included several stress analysts from the automotive industries; the discussion that followed the talk was therefore very animated and brought to light many additional facets of the stress analysis problem.

Memoranda: Ballots for electing the 1946-7 officers will be included in the next mailing of our regular news bulletin. Results of the election will be announced at the June meeting, the last technical session of the season. Plans for the summer include several social and recreational activities for members, their families and friends. A joint picnic with the Wayne County Section of the ISA will be a highlight of the summer season.

—S. KULKA, *Chairman, Publicity Com.*

NEW JERSEY

New Jersey had a most profitable May meeting with Mr. M. H. White speaking on "Selling an Instrument Department to Management." Mr. White drew on his wide experience with the Instrument Department at the Atlantic Refining Company's Philadelphia refinery. He outlined the fundamentals essential in selling a new department where none exists, showing the prime factors which management would require to judge its merits. He carried these thoughts further showing how, after formation of such a group, the management must continue to be sold.

Mr. White also stressed the importance of selling the Instrument Department at the other end of the line. He showed how the man in the Instrument Department in his relations with the operator is equally as important in this chain and how that man also must "sell" his work. The importance of carrying out this selling job at all levels was clearly brought out. Mr. White concluded his remarks by mentioning their annual report to management which is expected to be something of a horn blowing affair.

Such a lively discussion period followed with many questions from the floor, that our new president, Bill Ludi had to call the meeting to a close.

As the May meeting was our annual business meeting, reports of officers and committees were submitted. Results of the election of officers for the new year were also given: President, W. C. Ludi; Vice President, Sidney Baran; Secretary, H. S. Close; Treasurer, W. N. Maurer; Member of Board of Directors of National Society, Harry F. Moore.

Fifty-two members and twenty-two guests were present.

—H. S. CLOSE, *Secretary*

NEW YORK

The fortieth meeting of the New York Section, ISA, May 27, 1946, began with a dinner at the Men's Faculty Club, Columbia University, with thirty-eight members and guests present.

Prof. Kayan, Section President, opened the business meeting at 8:00 p.m. After reading of minutes and reports of committee chairmen, he introduced the speaker of the evening, Everett S. Lee, Engineer, General Electric Co., Generai Engineering & Consulting Laboratory.

Mr. Lee presented a lecture entitled "Measurements Unlimited," a very interesting story of men and instruments. He spoke of a number of persons and developments, mentioning the vital part that instruments held in indicating, guiding and proving each step toward their success and for the making of a better world in which to live.

—CHARLES DANA COREY, *Sec'y.*

PHILADELPHIA

On April 27th, the Philadelphia Section's field trip through the Marcus Hook, Penna., plant of the American Viscose Plant took place. The turnout of 45 was conducted through the rayon manufacturing plant in step with the natural sequence of operations from incoming wood chips to the finished spools of rayon. The group was unanimous in the opinion that the trip was well worthwhile.

At the April meeting, Mr. Daniel N. Kohn, Consulting Chemical Engineer, gave a most interesting talk on "Instrumentation in the Production of Fermentation of Ethyl Alcohol" before an attendance of 116. He covered generally the ramifications of alcohol as an industry, going back to an interesting historical point that Louis Pasteur discovered the enzyme which plays such a large part in the development of the mash.

Automatic control in regulating the mixture of water into the solids, cooking and cooling the mash before fermentation was discussed with particular emphasis on the difficulties peculiar to measurement and control of this type of solids.

He emphasized the considerable problem of disposal of so-called "slop" due to the fact that it cannot be permitted to escape into streams or rivers. This material is screened and concentrated in an evaporator or over a direct fired dryer to a material which can be compressed and is subsequently used for livestock feed.

Most of the difficulties in applying automatic control to these processes are due to the nature of the fluids and particularly the fact that the material will set up into a mass which will block valves and other orifices necessary to control.

A lively discussion followed which was particularly concerned with some applications of instruments for purposes which have heretofore defied the application of controls. A few of the comments on the subject of beverages were not at all concerned with instrumentation.

—J. J. FREGEAU,
Publicity Committee Chairman

Philadelphia Section American Viscose Corporation Field Trip

SAINT LOUIS

The St. Louis Section, ISA, held its regular May meeting (the final meeting of the year) at the York Hotel in St. Louis. No formal business: Entertainment and Refreshments. The meeting was designated as Manufacturer's Representatives Night, as the entertainment was provided by them.

During the dinner, an accordionist provided music and played request numbers. After dinner, a floor show was provided, with songs, dances, and acrobatics. Following the floor show, the members exercised their vocal talents on old favorites, with accordion and piano accompaniment. A plentiful supply of the beverage for which St. Louis is famous helped increase the volume output of some of the vocalists, if not the quality of their rendition. Card games were also provided for those wishing this type of entertainment.

The St. Louis Section wishes to thank the representatives of the following companies for their coöperation in making this meeting a success:

1. Leeds & Northrup Co.; 2. Foxboro Co.; 3. Taylor Instrument Cos.; 4. Weeks Engineering Co.; 5. Carl F. Gast Co.; 6. Technical Sales Co.; 7. Brown Instrument Co.; 8. Wheelco Instrument Co.; 9. Bristol Co.; 10. Hagan Corporation; 11. Claude S. Gordon Co.; 12. O'Brien Equipment Co.; 13. Davis Emergency Equipment Co.; 14. Economy Equipment Co.; 15. Bruce Greaves Co.

Attendance at the meeting was approximately 60 members and guests.

—H. E. ZEFFREN, *Secretary*

TENNESSEE SECTION

The Tennessee Section of the ISA held its annual meeting May 8th, at the Kingsport Inn, Kingsport. After dinner an election was held, and the following officers were elected: President, J. T. Elder; 1st Vice President, J. W. Selby; 2nd Vice President, Wilbur Watkins; Treasurer, A. W. Bright. President and Vice Presidents were elected for one year. The Treasurer was elected for two years. The office for Secretary was not voted on since the incumbent had been elected last June for two years.

Mr. G. L. Moorehouse made a report on the National meeting held at Detroit, April 4-6. Several people were interested in the Standardization Program that the National is sponsoring and it was recommended that our President appoint committees to make suggestions and aid the National Committees in their efforts for standardization.

Retiring President H. L. Jankey made his annual report, as did the Secretary and Treasurer. The meeting adjourned at 11:00 p. m.

—CHARLIE F. PALMER, *Secretary*

WYANDOTTE, Mich.

The Wayne County Section, ISA, met as scheduled on May 27. The dinner was excellent despite current shortages and other difficulties. There was a brief business meeting during which we held a minute of silence in observance of the recent death of a member, Dr. Richard Darbyshire.

Dr. W. N. Greer of Leeds and Northrup gave a talk, with blackboard illustrations, on pH measurement and control. He gave something of the history of pH cells and instruments. Several control applications were outlined and the accompanying problems were explained. There were several questions from the group.

—JOHN MACPHERSON, *President*

Other Societies

INDIANAPOLIS TECHNICAL INSTRUMENT SOCIETY

The regular meeting of the Indianapolis Technical Instrument Society was held on May 7, 1946, at Purdue University Center, 902 N. Meridian street.

Dr. F. T. Rodgers, Jr., of the U. S. Naval Ordnance Plant gave a very good talk on the "Basic Theory of the B-carbon Pile Type of Voltage Regulator." Dr. Rodgers developed the basic theory of the carbon pile regulator and pointed out that not too much is known about this type. There is a fundamental error in the regulator which can not be got rid of without destroying the regulation. His talk was very well received by all.

The By-Laws for the Society were approved at this meeting and we feel we have gotten off to a very good start this spring.

—MORRIS UNDERWOOD, *Sec'y-Treas.*

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The Industrial Instruments and Regulators Division of the American Society of Mechanical Engineers is planning a two-day meeting in conjunction with the ISA "Instrumentation for Tomorrow" Conference and Exhibit, September 16th to 20th, in the William Penn Hotel, Pittsburgh, Penna.

High-light of the meeting will be a symposium on "Controllability of Combustion Processes," to be held Monday afternoon, September 16th. Plans call for several papers followed by discussion from the floor.

On Tuesday, September 17th, two technical sessions will be devoted to particular phases of instrumentation.

Plans also call for an ASME-IIRD dinner, with an interesting speaker, Monday evening and luncheons on both Monday and Tuesday.

—T. G. BECKWITH

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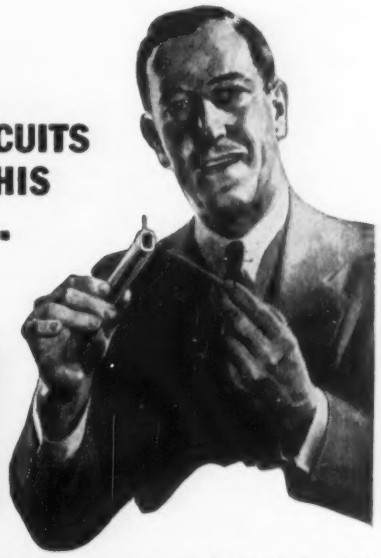

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I. S. A. SECTIONS

City, Section, and Secretary	Date and Place	Subject and Speaker
Baltimore, Md.; Baltimore Section, I.S.A., F. Ragan, Fuel Div., Beth. Steel, Sparrows Pt., Md.		
Charleston, W. Va.; Charleston Section, I.S.A.; M. B. Lorig, 1506 Virginia St., Charleston 1		
Chicago, Ill.; Chicago Section, I.S.A.; A. J. Butler, c/o IHC, 2626 W. 31st Blvd., Chicago		
Cleveland, Ohio; Cleveland Section, I.S.A.; A. J. McCullough, Minneapolis-Honeywell, 5005 Euclid Ave., Cleveland 3	**June 26**(B), Cleveland Eng. Soc.	Business Meeting.
Cumberland, Md.; Cumberland Section, I.S.A.; Carl Lower, LaVale Rt. 1, Cumberland, Md.	**June 25**(D), Queen City Hotel	"Representing Instrument and Control Manufacturers Precautions in Instrument Installations," Miflin Jacobs
Detroit, Mich.; Detroit Section, I.S.A.; J. D. McCullough, Horace H. Rackham Bldg., 100 Farnsworth, Detroit 2	**June 17**(D), Ethyl Research Lab.	"Pressure Gages," H. Colonese, Manning, Maxwell & Moore, Inc.
Gulf Coast (Tex.); Gulf Coast Section, I.S.A.; O. D. Sanders, Neches Butane Co., Port Neches, Texas		
Kansas City, Mo.; Kansas City Section, I.S.A.; O. L. Boutros, 1627 E. 31st St., Kansas City 3, Kansas		
Los Angeles, Calif.; California Section, I.S.A.; M. D. Pugh, 35 S. Raymond Ave., Pasadena 1		
Newark N. J.; New Jersey Section, I.S.A.; H. S. Close, 831 Dixie La., Plainfield, N. J.	**Oct. 1**, Essex House	"Shop and Equipment Requirements for an Instrument Dept. in a Large Plant in the Process Industry," W. Fortney, Humble Oil & Refining Co.
New Orleans, La.; New Orleans Section, I.S.A.; W. H. Haney, 1016 Esplanade Ave., New Orleans		
New York, N. Y.; New York Section, I.S.A.; C. D. Corey, Rieber Research Lab., 127 E. 73rd Street, New York 21	**June 17**(B), Men's Faculty Club, Columbia Univ.	"Some Problems Affecting Instrumentation in the Chemical Processing Industries," A. L. Chaplin, American Cyanamid Co.
N. Indiana; North Indiana Section, I.S.A.; C. P. Haynes, Red River Oil Ref., 935 177th Pl., Hammond, Ind.		
Philadelphia, Pa.; Philadelphia Section, I.S.A.; Clarence W. Wood, Mason-Neilan, 6908 Market St., Upper Darby, Pa.	**June 19**(B), Broadwood Hotel	"Instrumentation in European Refineries," Amos Keeler, Socony-Vacuum Oil Co.
Pittsburgh, Pa.; Pittsburgh Section, I.S.A.; L. M. Susany, c/o Carnegie Institute, 4400 Forbes St.		
St. Louis, Mo.; Saint Louis Section, I.S.A.; H. E. Zeffren, 5625 Enright Blvd., St. Louis 12		
Kingsport, Tenn.; Tennessee Section, I.S.A.; C. F. Palmer, 2924 J. C. Hwy., Kingsport		
Toronto, Ont., Canada; Ontario Section, I.S.A.; T. C. Agnew, Minneapolis-Honeywell		
Washington, D. C.; Washington Section, I.S.A.; G. M. Rolls, c/o American Instrument Co., 8010-8020 Georgia Ave., Silver Springs, Md.		
Wyandotte, Mich.; Wayne County Section, I.S.A.; Chas. Chessrown, P. O. Box 150, Wyandotte	**June 24**(B), Presbyterian Church, Wyandotte	"Electronic Specialties," Messrs. Barnum and Gramm.

OTHER SOCIETIES

(Events of which *Instruments* has been notified.

City, Society, and Secretary	Date and Place	Subject and Speaker
Akron, Ohio; The Akron Instrument Society; Fred Appel, Jr., 932 Columbia Court, Barberton, Ohio.		
Atlanta, Ga.; Georgia Society for Measurement and Control; John Roberts, 439 Deering Rd.	**June 24**(B), Ellen Rice Tea Room	Open Discussion and Business Meeting.
Ft. Worth, Tex.; Ft. Worth Electronics Club; W. H. Farrington		
Hartford, Conn.; Hartford Society for Measurement & Control; Gustave L. Manke, c/o Veeder-Root, Sargent & Garden Sts.		
Houston, Tex.; Houston Instrument Society; R. W. Fritsche, 630 A M & M Bldg., Houston 2	**July 1**(D), Houston Engineers Club	To be announced.
Indianapolis, Ind.; Indianapolis Technical Instrument Society; Morris Underwood, Indianapolis Power & Light Co., Indianapolis 6		
Kalamazoo, Mich.; Southern Michigan Instrument Society; F. R. Brydges, 223 Chestnut St., Battle Creek.		
Los Angeles; Southern California Meter Association; Charles Meriam, Publicity Chairman, 960 Mission St., South Pasadena, Calif.	**June 20**(B), Rio Hondo Country Club, Downey, Calif.	"Annual Low Jinks"
Sarnia, Ont., Canada; Sarnia Instrument Association; K. Williamson, 168 Cobden St., Sarnia		
Southwest Texas; South Texas Instrument Society; Homer C. Givens, LaGloria Corp., Falfurrias, Tex.		
Whiting, Ind.; Whiting Instrument Men's Guild; Fred T. Lucas, 1713 Myrtle Ave., Whiting, Ind.		

(A)Meeting at 7:30, no dinner (B)Dinner at 6:30, meeting at 8 (C)Dinner at 7, meeting at 8 (D)Meeting at 8, no dinner (E)Dinner at 6:30, meeting at 7:30

Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on page 387.

N-184 **Miniature Electrical Instruments.** 4-page 8½" × 11" folder describes and illustrates new "Models 102 and 152 MB Miniature Meters" available in all standard d-c. ranges as well as a-c. rectifier type voltmeters and milliammeters. Engineering information, prices and range of specific models is included. MB Mfg. Co., Inc., Instrument Div., 331 East St., New Haven 11, Conn.

N-185 **Falling Ball Type Viscosimeter.** 4-page 8½" × 11" Bulletin H-V 303 describes and illustrates the "Hoeppler Viscosimeter" for measurement of viscosity by falling ball method. Viscosity of fluids is determined instantly; results are reproducible; it is said an intelligent workman can measure viscosities more accurately with this viscosimeter than can a skilled scientist using usual empirical instruments. Fish-Schurman Corp., 230 E. 45th St., New York 17, N. Y.

N-186 **Electronic A-c. Voltmeter.** 8-page 8½" × 11" Bulletin No. 8 pictures and describes "Model 300 Ballantine Voltmeter" said to be about 100 times as sensitive as conventional electronic voltmeters, permitting readings down to 0.001 volt. The bulletin also describes numerous accessories for this instrument which permit a wide range of application. Ballantine Laboratories, Inc., Boonton, N. J.

N-187 **Automatic Voltage Regulation.** 12-page 8½" × 11" bulletin describes and illustrates the "Sorensen A-c. Voltage Regulators." It is claimed that these instruments are sensitive only to changes in voltage, having no moving parts and quick response thereby exceeding limitations of fundamental mechanical and magnetic type voltage stabilizers. Diagrams and applications of the instruments are included, also a listing of other products. Sorensen and Company, Inc., 375 Fairfield Ave., Stamford, Conn.

N-188 **Electrical Indicating Instruments.** 28-page 8½" × 11" catalog pictures and describes the complete line of "Marion Glass-to-Metal Truly Hermetically Sealed Electrical Indicating Instruments." Engineering and production facilities of manufacturer are shown in detail and engineering data and applications of individual instruments are given. Marion Electrical Instrument Co., Manchester, N. H.

N-189 **"Spectrographer's News Letter."** 4-page 8½" × 11" issue (designated Vol. 2, No. 1) of this house organ features an article, "Apex Smelting Zinc Die Cast Method" which describes a method of analyzing zinc die cast metal with speed and accuracy by spectroscopy. Data tables for the article and news of societies complete the issue. Harry W. Dietert Co., 9330 Roselawn Ave., Detroit 4, Mich.

N-190 **Flow Meter.** 8-page 8" × 11½" Bulletin F1603 describes and illustrates new "Bellows-differential Flow Meter," available as mechanical, electrical and pneumatic-transmission flowmeter in a complete line of recording, indicating, integrating and automatic-controlling models. It is said that a unique method, which isolates the meter-body shaft from the measured fluid, transmits bellows motion to pen-arm. The Bristol Co., Waterbury 91, Conn.

N-191 **Precision Resistors.** 4-page 8½" × 11" Bulletin No. 126 pictures and describes a new line of "Ohmite Riteohm Non-inductive Pie-wound Resistors," available from stock in 0.5-watt and 1-watt units in a wide range of values. Useful data and list prices are included. Ohmite Mfg. Co., 4835 West Flournoy St., Chicago 44, Ill.

N-192 **Metallized Glassware.** 4-page 8½" × 11" Bulletin EL-Z-Z10 pictures and describes "Corning Metallized Glass for the Electronics Industry." This glass provides combinations of high dielectric strength, high volume and surface resistivity, considerable range of dielectric constants and low power loss at all frequencies. Covered also are typical applications and the ease with which anyone can master the technique of making metallized glass to metal seals. Corning Glass Works, Corning, N. Y.

N-193 **A-c. Magnetic Relays.** 8-page 8½" × 11" Bulletin 550 illustrates and describes maker's line of magnetic relays for automotive, industrial, communication and electronic use. Relays are available single- or double-pole, 25-60 cycle, 1.5 to 220 volts. Included are applications, ratings and diagrams. R-B-M Manufacturing Co., Logansport, Ind.

N-194 **Thermometers.** 44-page 8½" × 11" Catalog No. 100 pictures and describes thermometers for industrial and laboratory use with "Moeller Glass Red Reading Column," also mercury-actuated dial thermometers, barometers, hydrometers, psychrometers and marine specialties. Specifications, diagrams and ranges of instruments are covered. It is claimed the "Red Glass" reading column offers the greatest contrast to mercury. Moeller Instrument Co., Richmond Hill, New York, N. Y.

N-195 **Water Works Instruments.** 4-page 8½" × 11" Bulletin 358 illustrates and describes instruments of interest to the water and sewage works field: differential producers, filter controllers and gages, counter and recording meters, large dial gages, manometers and ratio indicating gages. Builders-Providence, Inc., Providence 1, R. I.

N-196 **Supersonic Inspection of Forged Axles.** 6-page 8½" × 11" Reprint No 3000 is a reprint of an article by John C. Smack in Nov. 15 issue of *Automotive and Aviation Industries*, describing inspection of forged axles by supersonic waves. Sperry Products, Inc., Hoboken, N. J.

N-197 **Pneumatic Null Balance Pressure Regulator.** 8-page 8½" × 11" reprint of an article by C. B. Moore in Sept. 1945 issue of *Instruments* entitled "Solution of Instrumentation Problems by Pneumatic Null Balance Method." Moore Products Co., Philadelphia 24, Pa.

N-198 **Multi-position Electronic Pyrometer Controller.** 4-page Bulletin D4-2 describes and illustrates the "Multronic Capacitrol," a flexible pyrometer controller using two electronic control circuits, without mechanical contact, which

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Many Standard Mountings.

In addition to the housed model shown here, with its plug-in contacts, Bradley also offers tube socket, nut-and-bolt types and pig-tail contact mountings.

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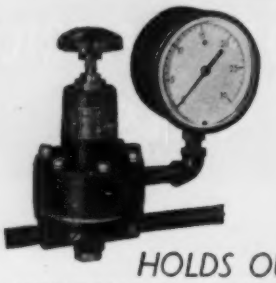


HOLDS OUTPUT PRESSURE CONSTANT

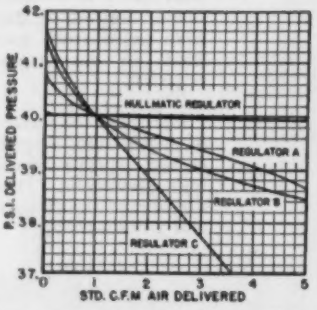
regardless of wide changes in flow or in supply pressure

This instrument is actually a pressure controller in which the main valve is operated by a pilot nozzle. Recommended for precision regulation of air and gas pressures, in dead-end service, and with flows up to a maximum of 45 s.c.f.m.

PERFORMANCE

The NULLMATIC Regulator provides accurate and dependable manual control of air-operated valves, dampers, and air-loaded cylinders. The automatic bleed feature permits lowering the control pressure when required. A separate safety release provides positive protection against overload.

EFFECT OF CHANGES IN FLOW



These curves show the slight effect of flow changes on the NULLMATIC Regulator, compared to the performance of several non-piloted instrument-type regulators. In the tests, each regulator was set to deliver 40 p.s.i. at 1 s.c.f.m. flow (with 60 p.s.i. supply), and this setting was maintained while the flow was varied. At 5 s.c.f.m., the NULLMATIC Regulator varied less than 1" H_2O delivered pressure.

Bulletin 402 shows standard ranges and performance

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MOORE PRODUCTS CO.

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operate in harmony with each other, but independently. It is claimed that control action is instantaneous. Wheelco Instruments Co., 847 W. Harrison St., Chicago 7, Ill.

N-199 **Galvanometers.** 38-page 7¾" × 10½" Catalog ED completely describes and illustrates a line of galvanometers for use in research, teaching and testing. It contains specifications for d-c. and a-c. galvanometers, reflecting and pointer types, astatic dynamometers, lamp-and-scale and telescope-and-scale reading devices and other accessories. Leeds & Northrup Co., 4911 Stenton Ave., Philadelphia 44, Pa.

N-200 **"7,000 Ways to Control Dimensions."** 48-page 5½" × 8¼" catalog pictures and describes gages for inspecting angle, concentricity, depth, height, curvature, length, inside diameter, thickness, thread and combinations of dimensions. Federal Products Corp., 1144 Eddy St., Providence 1, R. I.

N-201 **Manometers.** 8-page 8½" × 11" Bulletin 200 pictures and describes maker's line of fixed and portable manometers for use in water surveys and similar flow measurement. Included are engineering data on manometers. Simplex Valve & Meter Co., 6786 Upland St., Philadelphia, Pa.

N-202 **Pneumatic Positioners.** 8-page 8½" × 11" Catalog Section 55-A pictures and describes pneumatic transmitting accessories which may be applied to any rotameter type flowmeter. The transmitter is a magnetic clutch which picks up float movement and translates it into angular motion. The flowmeter's readings may be transmitted great distances to recorders equipped with bellows type pneumatic actuating motors. Fischer & Porter Co., Hatboro, Pa.

N-203 **Man-made Silica.** 2-page 8½" × 11" Folder EL-Z-Z12 describes and illustrates Corning "Vycor Glass No. 790," said to possess electrical and thermal properties available in no other commercially-produced glass. Metallized "Vycor" is also covered. Corning Glass Works, Corning, N. Y.

N-204 **Wire Gage Machine Reamers.** 10-page 8½" × 11" Price List No. 46 describes and illustrates a complete line of high-speed steel machine reamers in wire gage sizes, available from 1 to 60 gage or 0.2280" to 0.0400". It is said that dimensions stay put as these reamers are ground after hardening. La Vallee & Ide, Inc., Chicopee, Mass.

N-205 **Thermometers.** 16-page 8½" × 11" Catalog C-51 pictures and describes maker's line of etched stem thermometers and hydrometers with complete data and method of manufacture. Gotham Instrument Co., Inc., 149 Wooster St., New York 12, N. Y.

N-206 **"General Radio Experimenter."** 8-page 6" × 9⅜₁₆" Vol. 20, No. 11 issue of this house organ pictures and describes "Type 650 Impedance Bridge" and features two articles, "Multiple Photos with the Microflash" and "Measuring Lateral Motions in a Rotating System with the Strobolux." General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

N-207 **"Electronics Digest."** 48-page 5⅝" × 7½" issue No. 2 of this house organ pictures and describes new development of electronics at work. It includes articles on Stratovision, "Mot-O-Trol," fluorescent lighting, electrolytic tin plating, x-ray inspection and electrostatic air cleaning. Booklet contains an explanation of the electron theory; and most articles are non-technical digests of material previously published. Westinghouse Electric Corp., Pittsburgh, Pa.

N-208 **Recording and Indicating Instruments.** 12-page 8½" × 11" Catalog 370 illustrates and describes maker's full line of recording and indicating instruments: for temperature, pressure, humidity, flow, liquid level, density and other process variables. The new "Dynalog" line is also covered. The Foxboro Co., Foxboro, Mass.

N-209 **Low-resistance Ohmmeter.** 4-page 8¾" × 10½" Bulletin 1805 pictures and describes three types of "Megger" instruments for measuring low resistances: "Bridge-Meg Resistances Tester," "Ducter Low Resistances Ohmmeter" and "Midget Megger Circuit Testing Ohmmeter." All instruments are for shop or laboratory use. James G. Biddle Co., 1211 Arch St., Philadelphia 7, Pa.

N-210 **Water-steam Mixing Valve.** 4-page 8½" × 11" bulletin pictures and describes operating features of the "Type M-700" 1" water-steam mixing valve, said to produce hot water as needed and minimize heat loss and operating cost. Hammel-Dahl Co., 243 Richmond St., Providence 3, R. I.

N-211 **Oxygen Recorder.** 12-page 7¾" × 10½" Bulletin 151 describes and illustrates "Bailey Oxygen or Excess Air Recorder," said to have high sensitivity to change in oxygen content, easy installation and sturdy construction, having no galvanometer or other delicate moving parts. Bailey Meter Co., Cleveland 10, Ohio.

N-212 **Strip Chart Potentiometer.** 20-page 8" × 10½" Catalog 15-8 pictures and describes "Brown Continuous Balance Potentiometer." Operating, constructional features and scale ranges are included. It is said that this instrument was used during the war on bombers as well as fighters for flight test purposes. Brown Instrument Co., Philadelphia 44, Pa.

N-213 **Conductivity Cells.** 12-page 8½" × 11" Catalog 12 illustrates and describes a wide selection of conductivity cells for checking of various liquids under varying conditions. A reference chart with constants and mechanical design of the cells is included. The catalog also covers sample coolers, cell holders, conductivity bridges and the "Solu-Bridge" and "Solu-Bridge Controller." Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.

N-214 **Precision Cleaning.** 8-page 8" × 10½" bulletin pictures and describes "Eng-Sol" method of high-velocity atomized spray cleaning for ball and jewel bearings, gear trains, gages, lenses and precision parts. This method is said to have twofold cleaning action: atomized solvent flushing away soluble matter and air blast driving out insoluble particles. Passaic Analytical Laboratories, Inc., Passaic, N. J.

N-215 **Metal Detector.** 4-page Folder Form IR9380 pictures and describes the "RCA Electronic Metal Detector," an automatic inspection device for detection of metal particles in non-metallic materials such as foods, rubber, lumber, plastics, cloth, felt and explosives. Radio Corporation of America, Camden, N. J.

N-216 **Resistors and Rheostats.** 16-page 8" × 10½" Catalog D-2 illustrates and gives complete data on wire-wound vitreous enameled resistors used by radio, television, radar and other electronic industries. This is the first catalog compiled by the manufacturer expressly for the electronic industries. Ward Leonard Electric Co., 31 South Street, Mt. Vernon, N. Y.

N-217 **Electrical Indicating Instruments and Automatic Regulators.** 20-page 8½" × 11" Catalog No. 46 pictures and describes panel instruments, automatic synchronizers, frequency regulators and other control equipment. Explanations and dimensional drawings as well as ranges, scale divisions and resistances are included. Burlington Instrument Co., Box No. 589, Burlington, Iowa.

N-218 **Micro Switches in Gaging Devices.** 16-page 8½" × 11" Bulletin No. 36, pictures and describes the use of precision snap action switches in sorting and gaging devices and shows the use of snap switches in limit, safety and con-

trol circuits. Micro-Switch Division, Freeport, Illinois.

N-219 **Micro Manipulator.** 4-page 8½" × 11" folder illustrates and describes the "Gamma Micro Manipulator" for experimental operation with the aid of micro needles, micro pipettes and other micro instruments under the microscope. Also covered is an automatic needle drawer and two types of moist chambers for biological and chemical operations. Gamma Instrument Co., Inc., 95 Madison Ave., New York 16, N. Y.

N-220 **Ceramic Capacitors.** 4-page 8½" × 11" folder illustrates and describes maker's "CN Type Capacitors" for radio and electronic use. Electrical Reactance Corp., Franklinville, N. Y.

N-221 **"Pittsburgh-Empire Water Journal."** 16-page 8½" × 11" issue of this house organ, Vol. 30, No. 1, contains pictures and information on the operation of waterworks and sewage treatment plants. Featured are three articles: "Flood Control and its Benefits," "Fluorine," and "What Stream Conservation Means to Industry." Pittsburgh Equitable Meter Div., Rockwell Mfg. Co., 400 No. Lexington Ave., Pittsburgh 8, Pa.

N-222 **Portable Pyrometer.** 2-page 8½" × 11" Bulletin 3879 illustrates and describes the "Alnor Type 1500" pyrometer mounted in a magnetically-shielded metal case, for industrial laboratory use; available in ten scale ranges, 0-400° to 0-3000°F. Illinois Testing Laboratories, Inc., 420 N. La Salle St., Chicago 10, Ill.

N-233 **Differential Pressure Gages.** 2-page 8½" × 11" Catalog Sheet No. 921 illustrates and describes a line of diaphragm-operated differential pressure gages for test and research work, graduated in inches of water or of mercury. Kollsman Instrument Division, Square D Company, Elmhurst, N. Y.

N-224 **Precision Gage Blocks.** 36-page 6" × 8¾" catalog describes and illustrates maker's "Micro-Accurate" gage blocks, outlines manufacturing process, gives detailed instruction for care and suggestions for use. Heavy-duty blocks with special assemblies produce height gages said to assure microinch accuracy in setting; also inside or outside calipers or precision dividers. Webber Gage Co., 12900 Triskett Rd., Cleveland 11, Ohio.

N-225 **Combustion Control Instruments.** 8-page 8½" × 11" bulletin illustrates and describes precision draft gages, pressure gages and the "Thermogage," a flue gas temperature indicator. Also covered are the "Dampertrol" operating on draft or air pressure and the "Steamtrol" operating from steam pressure, both actuating the "Lectricarm," a floating or step regulator used for operating dampers, stokers, rheostats, etc. Cleveland Fuel Engineering Co., 606 Williamson Bldg., Cleveland 14, Ohio.

N-226 **Electronic Process Timer.** 12-page 8½" × 11" Bulletin 950 illustrates and describes an adjustable timing relay with immediate automatic resetting for timing periods from 1/20 second on; designed for single actuation as well as for sequence timing and recycling in continuous operation. Photovolt Corp., 95 Madison Ave., New York 16, N. Y.

N-227 **Wire Wound Resistors.** 4-page 8½" × 11" folder illustrates and describes with complete specifications the "Hi-Q" line of fixed rating wire wound resistors. Stock sizes and ratings are available from 1 ohm to 250,000 ohms. Electrical Reactance Corp., Franklinville, N. Y.

N-228 **Heavy-duty Fatigue Test Equipment.** 4-page 8½" × 11" Bulletin V-1 illustrates and describes "Vibrok" vibration and rocker test machines for heavy aircraft components and industrial products weighing up to five tons. Machines vibrate, rock or slosh test-specimens, such as motors in operation, loaded gasoline tanks and machine tools requiring

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mounting areas as large as 77″ × 108″. Globe Industries, Inc., 125 Sunrise Pl., Dayton 7, Ohio.

N-229 **Precision External Gaging.** 4-page 8½″ × 11″ Bulletin No. 30 illustrates and describes "Series M" comparator "Comtorgage" for gaging cylindrical work to a fraction of 0.001″ while still in machine without stopping work. Comtor Company, Waltham, Mass.

N-230 **Portable Pitot Recorder.** 20-page 8½″ × 11″ Bulletin No. 50, pictures and gives complete details of use of "Simplex" Pitot tubes and rods, instructions in use of portable pitot recorder, together with theory, formulas, notations, tables and curves of use with "Simplex" Pitot tubes, manometers and recorders. Simplex Valve and Meter Co., 6786 Upland St., Philadelphia 42, Pa.

N-231 **Silver Electrode Ceramic Capacitors.** 4-page 8½″ × 11″ bulletin illustrates and describes the "Hi-A" line of silver electrode ceramic capacitors of the C.I. type. Construction details and specifications are included. Electrical Reactance Corp., Franklinville, N. Y.

N-232 **Unbonded Resistance Gage.** 2-page 8½″ × 11″ Catalog Sheet Y-1 illustrates and describes the "Statham Gage," a small 3½ oz. pick-up element permitting electrical indication or recording of small displacements or forces applied longitudinally to a projecting bar. Statham Laboratories, 8222 Beverly Blvd., Los Angeles 36, Calif.

N-233 **Measuring, Indicating and Totalizing Meter.** 8-page 8½″ × 11″ Bulletin 46-766 illustrates and describes the "Hays Totalizing Indicating Veriflow Meter" for most liquids, which combines positive volumetric measurement with rate-of-flow indication. Proportioning of two or more liquids is said to be handled

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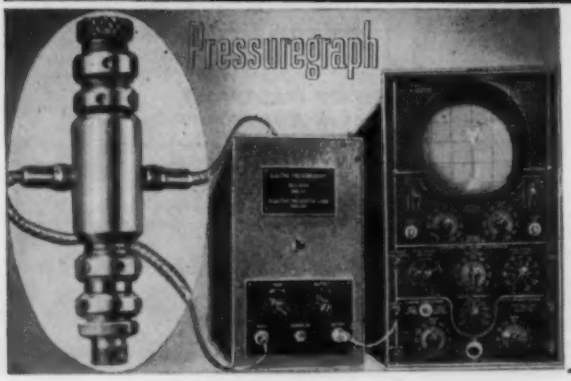

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N-234 **pH Control Instruments.** 28-page 8½" × 11" Bulletin pH 1302 illustrates and describes in detail continuous pH controllers and recorders, including electrode assemblies, accessories, chart records, flow diagrams, engineering and technical information relative to pH theory and measurement. The Bristol Company, Waterbury 91, Conn.

N-235 **Continuous-reading pH Meter.** 4-page 8½" × 11" Bulletin No. 2 illustrates and describes the "Macbeth Line-operated Continuous-indicating Direct-reading pH Meter" which has only one operating control, adjusted initially in standardizing the meter with a buffer solution. Meter operates on 115 volts and can be left on continuously as it is said to drift only 0.1 to 0.2 pH in 24 hours after temperature equilibrium has been reached. Macbeth Corporation, 227 W. 17th St., New York 11, N. Y.

N-236 **Photoelectric and Electronic Controls.** 24-page 8½" × 11" catalog pictures and describes photoelectric and electronic controls which can be incorporated in the design of any electrically-operated machine or installed on existing machinery. Fifty types are available for control of liquid level, turbidity, timing, counting, smoke and fire control. Photoswitch Inc., Cambridge, Mass.

N-237 **Boiler Feed Flow and Water Level Regulator.** 4-page Bulletin 449 describes and illustrates a two-element regulator for boiler feed control, one element responsive to load change; the second to level variation; easily adjusted to desired water level characteristics on base or fluctuating loads. Northern Equipment Co., 1051 Grove Drive, Erie, Pa.

N-238 **Thermal Limit Flow Controller.** 4-page 8" × 10½" Bulletin T829 illustrates and describes "Milk-flow Thermal Limit Controllers" which automatically operate a milk flow diversion valve or stop the pump on high-temperature short-time and vat-holding pasteurizing systems. Temperature and variation of operation are recorded. Bristol Company, Waterbury 91, Conn.

N-239 **Volt-ohm-milliammeter.** Single sheet 8½" × 11" describes and illustrates "Model 32" volt-ohm-milliammeter with 5000 ohms per volt sensitivity. Resistances as low as 2 ohms may be estimated, and zero does not need resetting in switching from one range to another. Meters Inc., 915 Riveria Drive, Indianapolis 5, Ind.

N-240 **Recording and Control Instruments.** 12-page 8½" × 11" Catalog No. 46 illustrates and describes an operation recorder capable of indicating and recording 25 operations per minute indicating length of each operation. Other instruments covered are diesel protecting systems, pyrometer and annunciator alarm, salinity indicators, hand pyrometers, electromagnetic balance, balance analyzer and shaft revolution indicator and counter system. The Instrument Laboratory, 934 Elliot Ave. W., Seattle 99, Wash.

N-241 **Color Matching Skylight.** 4-page 8½" × 11" Bulletin No. 107 illustrates and describes the "MacBeth Skylights" for color matching. They are air cooled, two variant color-matching units designed to provide diffused true "north sky daylight" and "horizon sunlight" over a large area in the manufacture of paper, inks, paints, colors and plastics. MacBeth Daylighting Corp., 227 W. 17th St., New York 11, N. Y.

N-242 **Differential Pressure Regulator.** 4-page 8½" × 11" Bulletin No. 1245 illustrates and describes "Hagan Type 2-SO Regulator," designed to regulate ratio of pressures or differential pressure. Features are wide operating range, spinning pilot valve, positive action and

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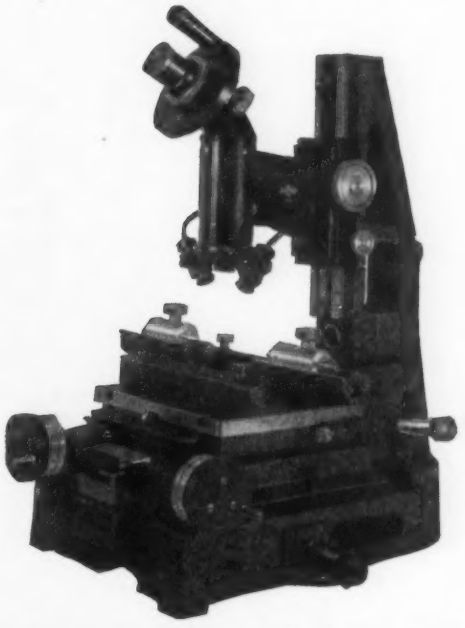

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adjustable response. Applicable to control of suction, pressure, flow ratio and fuel-air ratio. Hagan Corp., Hagan Bldg., 323 4th Ave., Pittsburgh, Pa.

N-243 **Wire Wound Resistors.** 16-page 8½" × 11" file catalog illustrates and describes with electrical specifications and physical dimension 26 types of "Microhm" wire wound resistors. Valves up to 1 megohm are available in inductive and non-inductive windings, ratings from ½ to 50 watts. Precision Resistor Co., 334 Badger Ave., Newark 8, N. J.

N-244 **Electronic Components.** 32-page 8½" × 11" Catalog RC6 describes and illustrates electronic components, fixed and variable resistors, iron cores, line and slide switches, carbon and powder metallurgy specialties. Specifications, reactance charts and other data are included. Stackpole Carbon Co., St. Marys, Pa.

N-245 **Midget Relays.** 20-page 8½" × 11" Catalog AR-1-45 describes and illustrates "Aerotrol 400 Series Magnetronic Relays" originally developed to meet aircraft requirements, said to be adaptable to electronic control applications in measurement, selection, radio, radar, wire communication, and testing. All relays may be "Stratopaxed" (sealed in inert gas). Cook Electric Co., Chicago 14, Ill.

N-246 **Automatic pH Control.** 12-page 7¾" × 10½" Bulletin N-96-709C illustrates and describes latest "Micromax" pH controller for use in cane sugar mills, said to hold lime flow to a steadiness previously unattainable. Included is a description of a glass electrode assembly claimed to hold its calibration and be remarkably free from maintenance. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

N-247 **Electrical Indicating Instruments.** 28-page 8½" × 11" catalog illustrates and describes standard instruments which incorporate the same quality materials and design as the hermetically sealed group. Included are milliammeters, microammeters, Gauss meters, null indicators, multi-range meter testers and direct-reading fluxmeters. Hermetically-sealed instruments are also covered. Marion Electrical Instrument Co., Manchester, N. H.

N-248 **Electric Temperature and Pressure Controllers.** 8-page 8½" × 11" Bulletin 4513T illustrates and describes temperature and pressure controllers for marine, industrial, aircraft and special applications. Models are built to regulate temperatures in air, liquid and hot-plate applications. Operating and range data are included. United Electric Controls Co., 69-71 A St., Boston 27, Mass.

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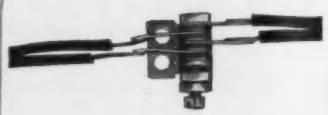

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